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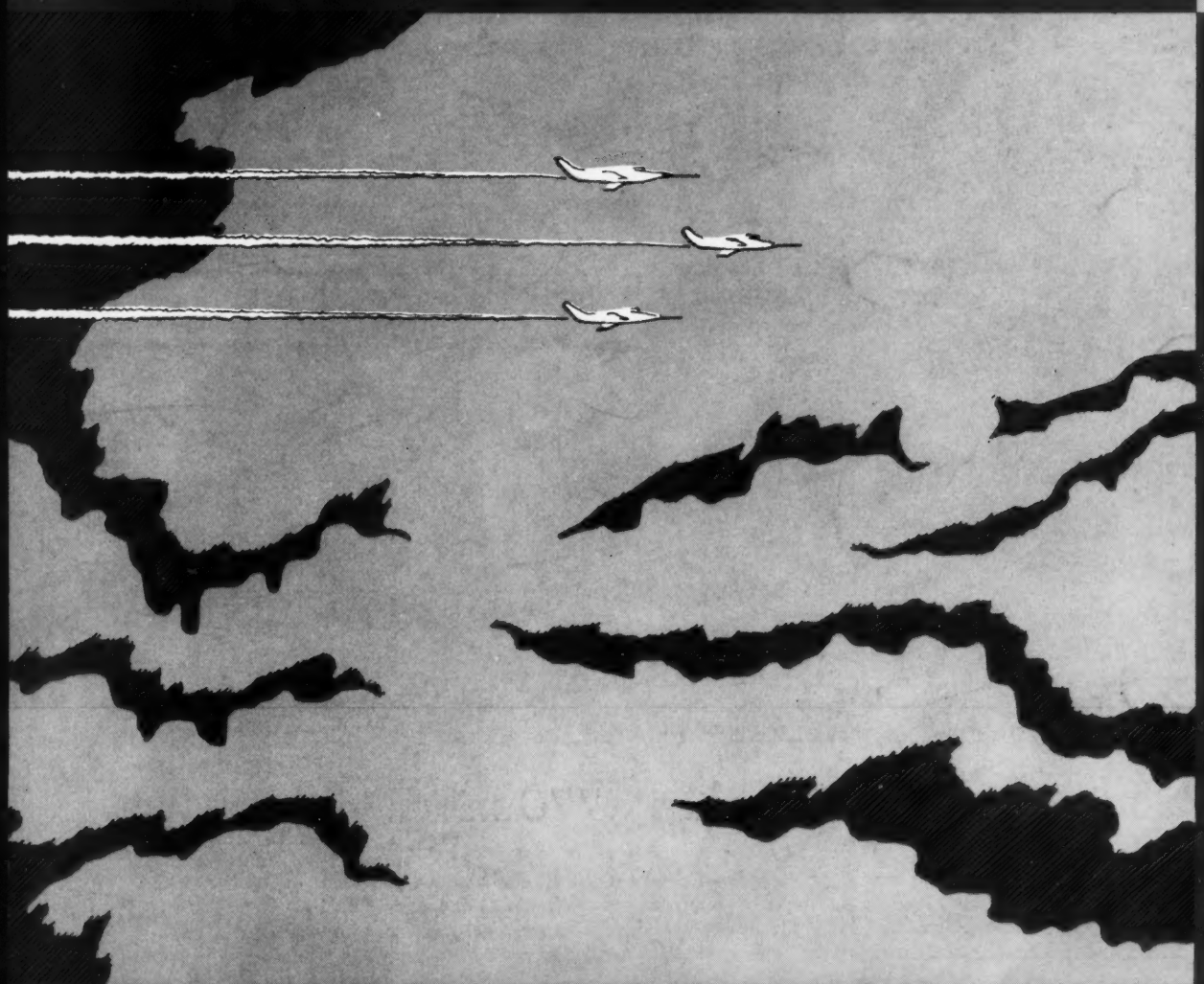

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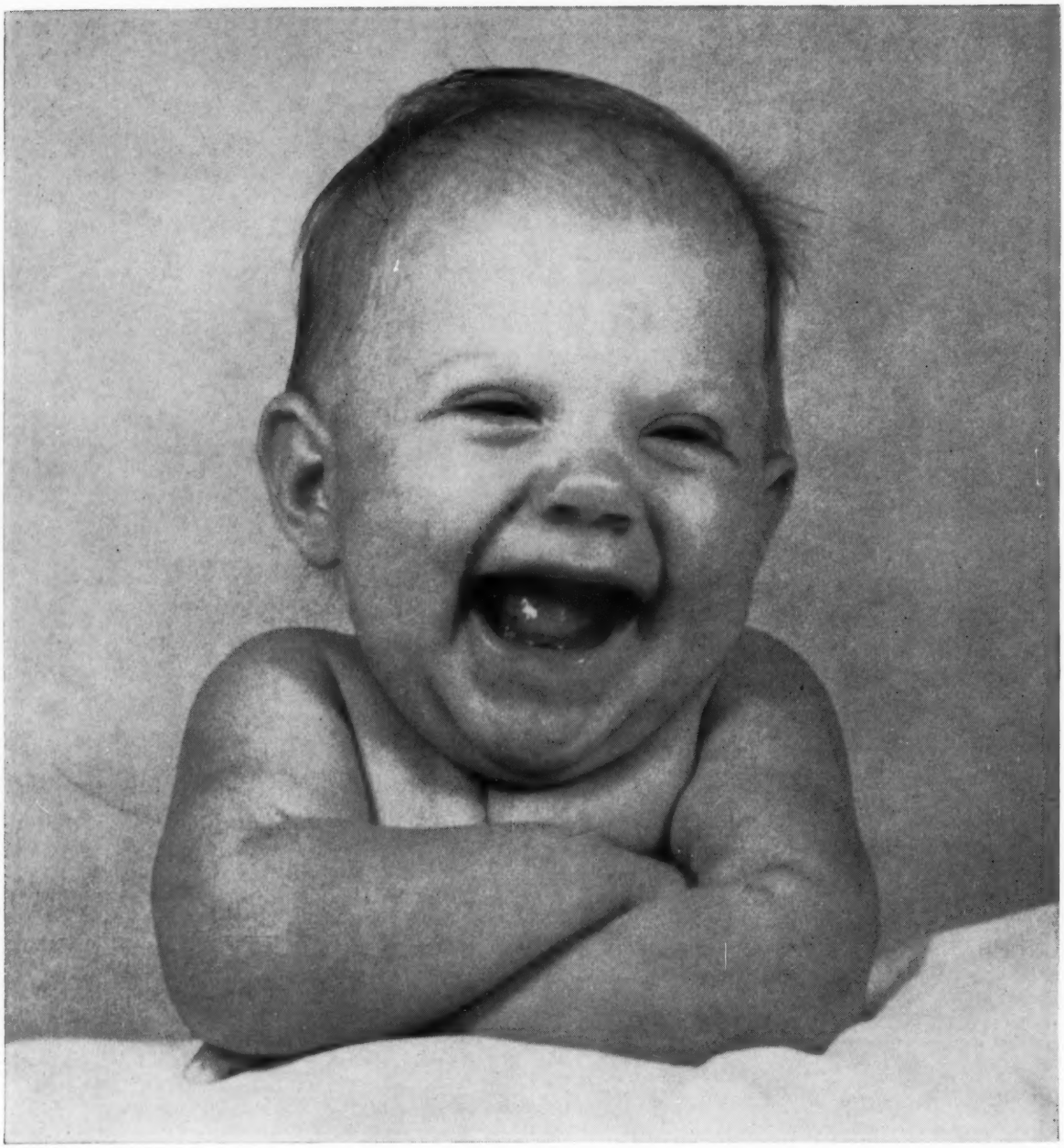

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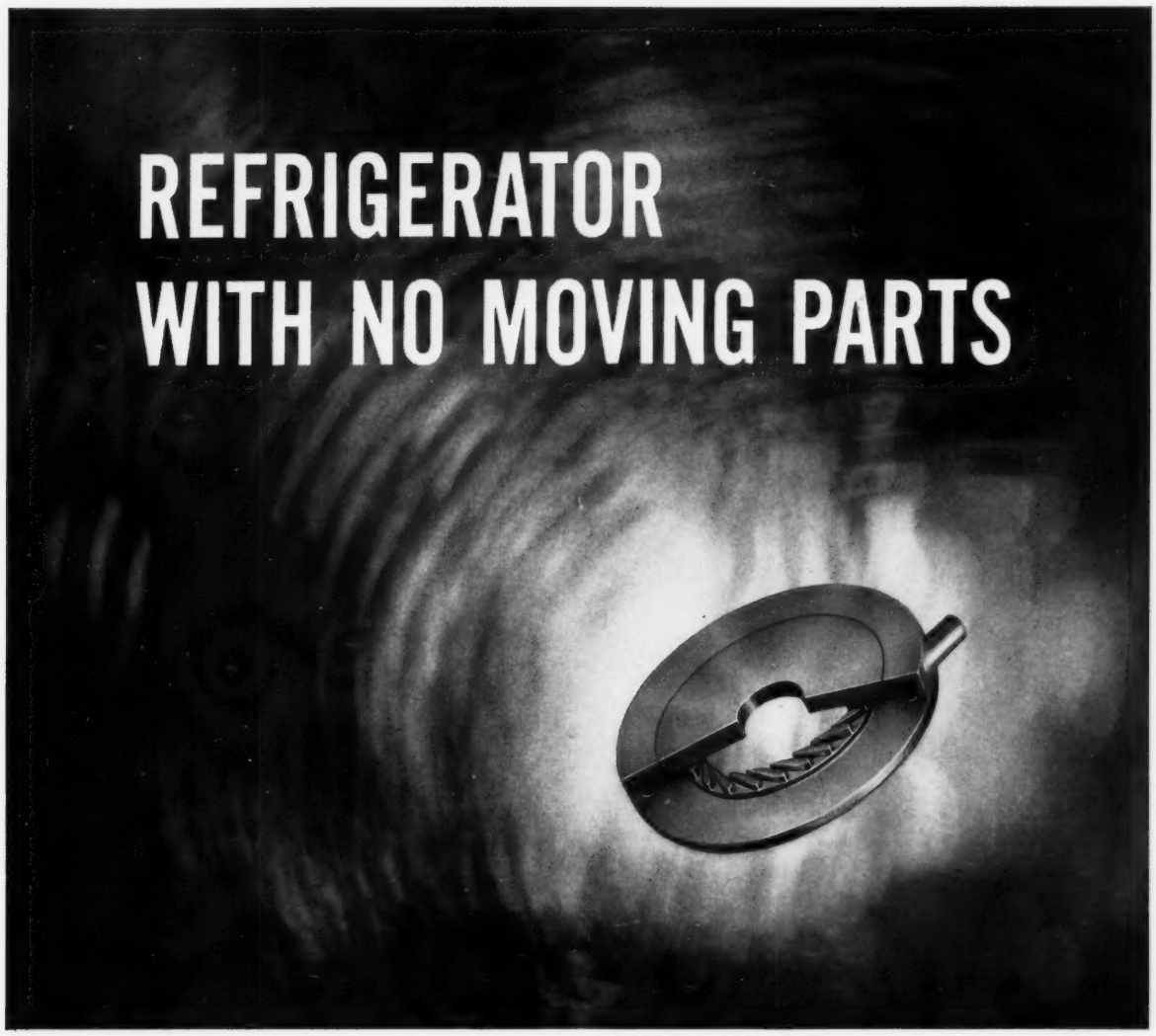

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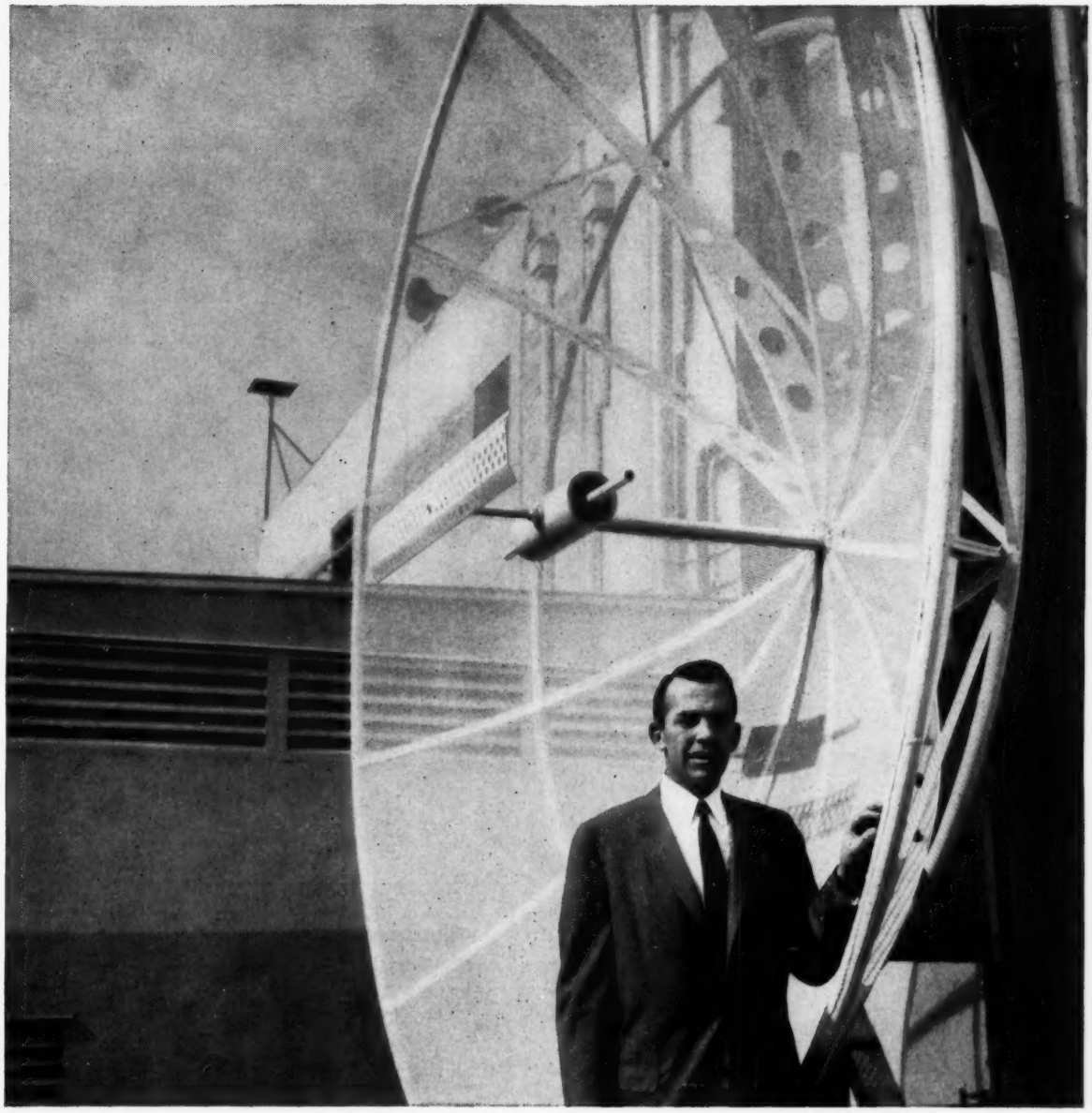

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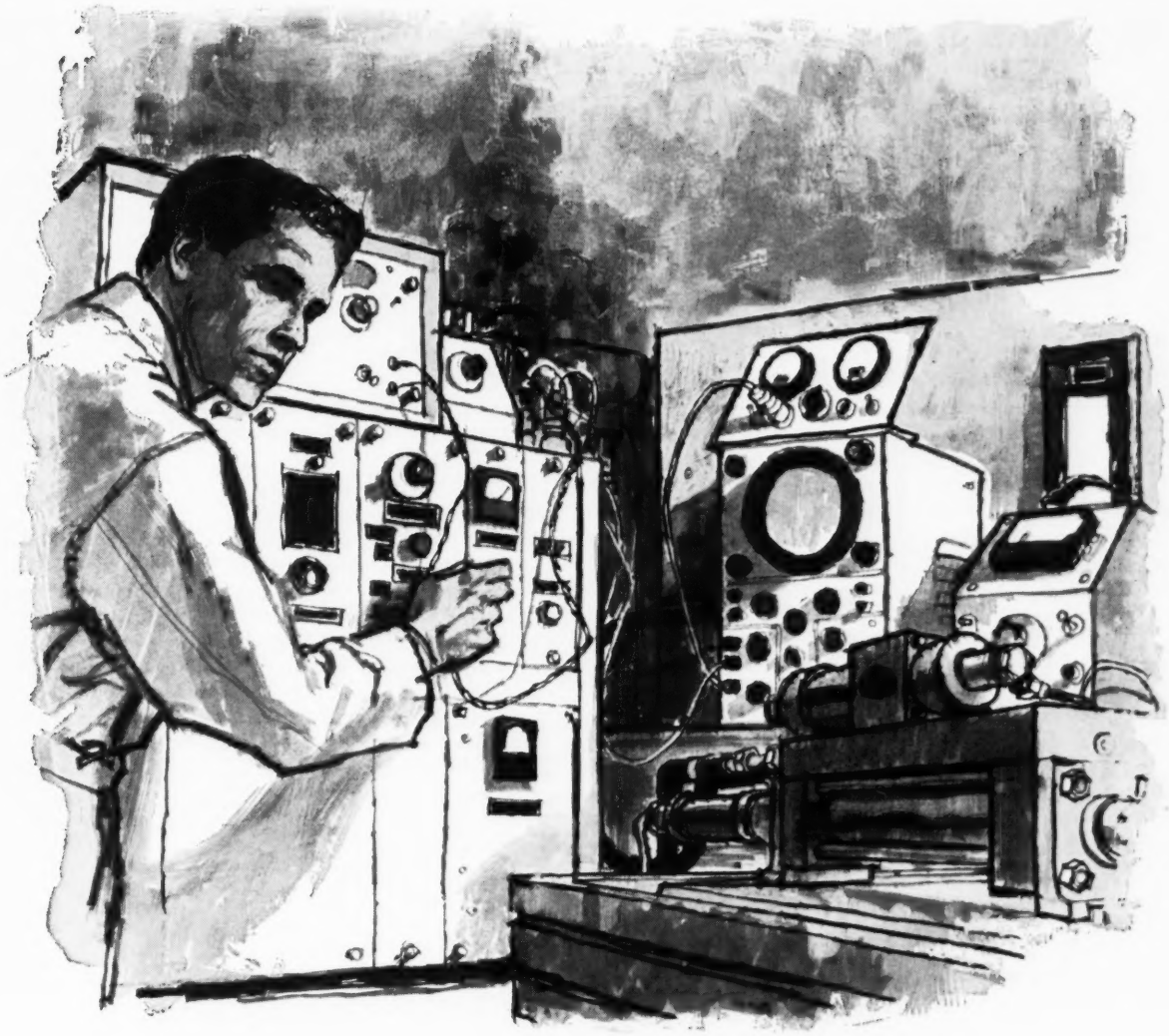

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Editorial:

REINTERPRETING THE ENROLLMENT STATISTICS

With the 1959 matriculation figures soon to be released, we are reminded of a report recently compiled by the American Society for Engineering Education. It states that despite "still-critical" demands for engineering talent, the 1958 enrollment in American engineering schools showed a significant decline. Nationally, there was an 11.6 per cent decrease in freshman engineering enrollment, a 6 per cent decrease in sophomore enrollment, and a 4 per cent decrease in junior enrollment.

These statistics are no surprise. Here at Cornell, upper class enrollment has remained substantially unchanged, but the number of freshmen has decreased significantly, along with the number of 1959 engineering applicants.

The concern of educators about the matter is no secret. Our country always needs well-trained, clear-thinking graduates; particularly those with technical backgrounds.

Engineering educators give three main reasons for high school students' slackening interest in engineering. The first of these is the 1957 recession. At that time, a number of engineers lost their jobs, and the situation was quick to attract notice. The public, however, was not as well informed of the fact that these people were soon rehired. Then too, the recession made many question the reliability of reports about a serious engineering shortage.

The second reason given for the downward trend in engineering enrollment is the present fanatical interest in "science." Ever since the Russians fired their first satellite, any high school student who had completed a few basic science and mathematics courses felt that science was his calling. Engineering? No! The scientists are the ones who launch all the missiles! We would really like to know where such individuals feel science stops and engineering begins. If there is such a tremendous distinction between the two, try to separate them and see how many missiles we launch!

The final reason given for waning interest in engineering training is its difficulty. We cannot argue with those who decide against engineering studies because of the hard work involved. There is little question that an engineering curriculum is a difficult one. The work required must be exacting in order to train the individual in the rigorous disciplines of engineering thought.

We fully agree that these three factors have been major causes for present enrollment decreases. But those who discard engineering for the first two reasons are making a mistake. A person is perfectly justified in rejecting engineering because he feels it is too difficult for him, but anyone who eliminates it as a possible career because the shortage no longer exists or because he wants to be a "scientist" far removed from engineering doesn't know what engineering education is and probably has a confused picture of what constitutes a scientist.

Engineering education is not merely a form of vocational training. If it were, there would be some justification for rejecting it when the shortage ends. The curriculum, however, gives much more. It is primarily training in the art of rigorous, analytical thinking. The engineer is confronted with problems that must be solved correctly the first time. An error in judgment on his part could have drastic results; consequently, he must be able to gather the pertinent facts, analyze them, and arrive at a correct decision.

The usefulness of such ability is not limited to engineering fields. These ordered methods for reaching correct conclusions are certainly vital to a scientist's success. Industry could not function if it did not have individuals versed in these disciplines to fill positions of high responsibility. A good engineer is familiar with a clear, logical method for attacking problems and pursuing them to completion. Few undergraduate courses provide such training. Its value is indisputable.

If the decrease in engineering enrollment meant that we were going to have fewer capable graduates, there would indeed be reason for serious concern. We believe, however, that individuals who apply to engineering schools today, while they may be fewer in number, have a clearer concept of what to expect from the course. Those who would pursue the course for purely economic reasons and those who feel they want "science" without engineering do not seek entrance into engineering programs. The remaining applicants should, therefore, have sound motives for seeking an engineering degree.

At present we must concentrate on informing prospective engineers of the training that is really involved. High school guidance counselors, admissions officers, alumni, and industry must convey this information. If they are successful, we can be even more confident that engineering applicants will be properly motivated. If the Class of '64 has a clearer concept of the intellectual challenge before it, a large entering freshman class will be unnecessary because the attrition rate will surely decline. Moreover, we will be able to look forward to graduating a group of exceptionally high quality students, better equipped to enrich the society in which they live.—A.S.R.

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THE CORNELL

engineer

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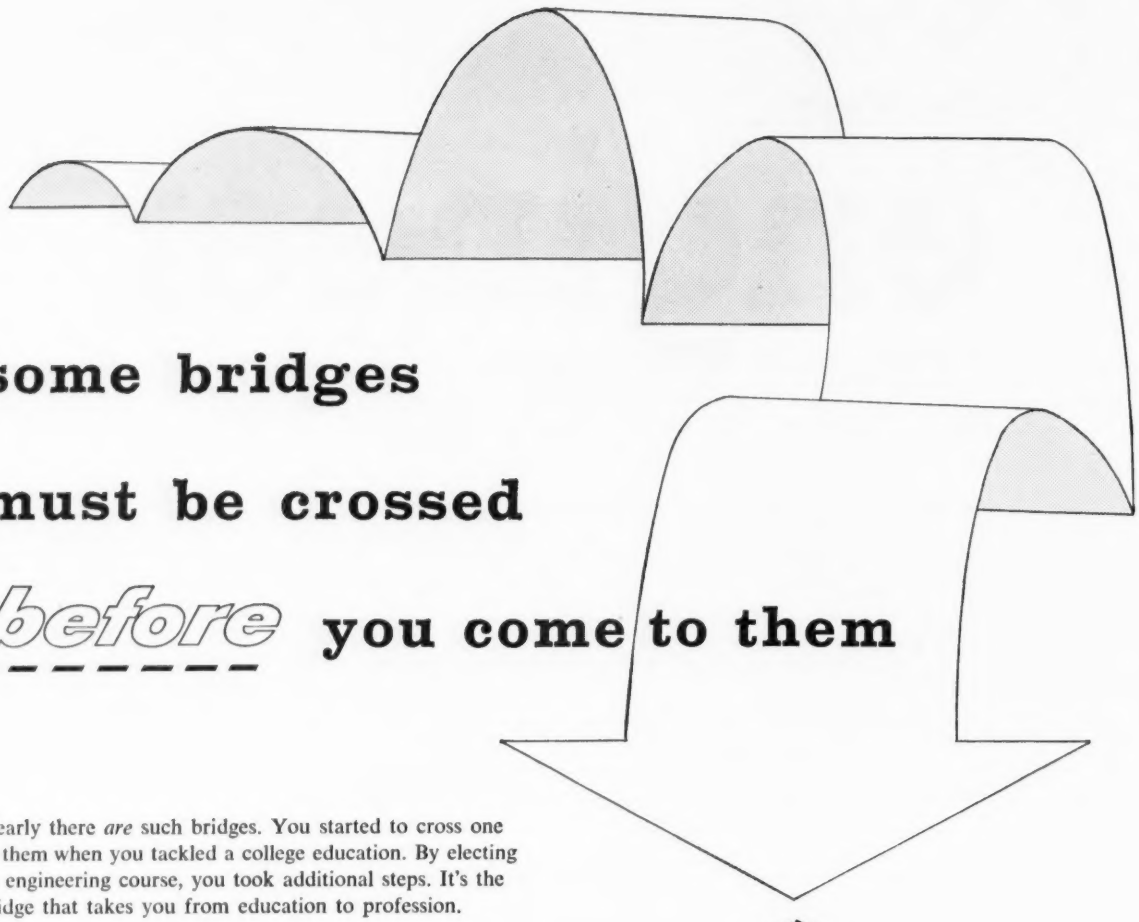

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Extensive Systems of Modern Air Traffic Control Provide . . .

SAFETY IN THE SKIES

by Mary Ann Huber, CE '63

"Request landing instructions," announced the loudspeaker. One of the three men at the control panel switched on his microphone and began the series of orders to the unknown pilot, another scanned the skies for the plane's approach. In a matter of minutes the craft touched down on the runway, and the two exchanged a satisfied glance and began the brief wait for the loudspeaker's next summons.

The scene might have taken place at any of the nation's hundreds of airports. It is a tiny link in a steadily lengthening chain, the business of air traffic control. Control of the airways covers a sweeping field, and it ranges from a pilot's glance from his cockpit window to huge control centers for metropolitan areas.

The history of air traffic control is almost as old as that of commercial aviation itself. Flying as a commercial venture began in 1926, and by 1930 a young engineer named Herbert Hoover had succeeded in developing one of the most valuable aids to pilots—the two-way radio. During the thirties, airplane design made huge strides; more powerful engines were built, streamlining was introduced; aircraft gained in size and speed. The triumph of the new technology was the DC–3. Its advent in 1936 gave commercial aviation the boost it needed to make it a paying enterprise. Passenger service mushroomed practically overnight with the introduction of this plane that could carry so many people with such speed. The confidence of the public in aviation grew because of new safety devices, among which were the automatic pilot and deicing systems on the leading edges of the planes' wings.

Ground control of the airways had its roots in the incident of a near-collision of two planes in a fog over the airport at Newark, New Jersey. Several aircraft companies instituted a system which enabled them to see that no two planes planned to occupy the same air space at the same time. From Newark, the idea rapidly spread in succession to Chicago and Cleveland. At this point, the government stepped in and took over the reins of control.

The next milestone in the growth of air traffic control came with World War II. Airports not only had to handle the ordinary civilian traffic, but also had to shoulder the added burden of military aircraft. The number of planes handled per hour tripled in a short period of time. Still, not many advances had been made in the mechanics of controlling this increasing traffic, and while the volume grew rapidly, control lagged behind. Instrument approaches were made on a four-course, low frequency radio range. Several relays of messages through airline offices and government stations were necessary to secure clearance to land. This situation severely restricted the number of landings per hour.

The first step toward alleviating congestion at airports was taken by delegating authority over approaching planes directly to the airport control tower. The tower personnel were assigned certain radio frequencies which enabled them to stay in direct communication with the pilot the entire approach period. This new "approach control" resulted in the reduction of the time for an instrument landing from fifteen minutes to only three. Although this solved the problem for the pilots, it created a new problem for the route control centers. Airports could now land planes faster than the centers, with their disorganized communications systems, could give them clearance to enter the airport area. This was remedied by supplying these centers also with direct radio to the aircraft.

Radar Aids Control

Air traffic control took another giant step with the introduction of radar. Although it was first used merely as a landing aid, the instrument's potentialities as a medium for control soon became evident. Since it gave observers a visual means of control, radar enabled planes to switch spacing from a time basis (two or three minutes apart) to a distance basis. This development also created problems for approach control, which still operated under older systems. It was necessary to reduce the spacing of planes entering the terminal area from ten minutes to three miles. Radio transmitters were set up to relay directions for orderly arrival from the Air Route Control Centers to planes 100 miles from the airport.

The use of radar enormously reduced the delays in landing aircraft at busy terminals. It eliminated much of the need for stacking at airports, but the need for this procedure still exists around many metropolitan areas. "Stacking" means that incoming planes are directed to fly in circles at different altitudes until the runways are ready to handle them. As the plane at the lowest altitude is landed, the planes above it move down one level. In the busiest

←

The Idlewild Control Tower guides air traffic entering and leaving the airport by use of electronic aids, the newest of which were recently installed in the dome atop the tower.

The Port of N.Y. Authority

areas, there may be as many as twelve planes in a stack, with an auxiliary stack a few miles away. This results in delays of up to forty minutes in the landing procedure.

Another inconvenience being eliminated as a result of radar installation is the practice of "fix-posting." Under this system, airplanes report their positions as they pass over certain points, and these "fixes" are posted on flight progress strips. A plane can not receive clearance to pass over a given check point until ten minutes has elapsed since the passage of the last plane, unless it is flying at at least a 1000-foot difference in altitude. The advantage of radar control becomes obvious when the increase in airplane speed is considered. Since 1940, the cruising speed of planes has increased from 220 to 600 miles per hour. Although the time limit has remained constant, the new speeds have resulted in an increase of sixty miles in spacing between planes. With radar control, this distance can be reduced to a practical one of about five miles.

The sequence of aircraft landings has also been altered by radar. Formerly, if a fast plane passed a "fix" after a slower craft, but passed the slower plane before coming to the next "fix," it would be forced to wait until the slower plane passed the second "fix" before proceeding on its own approach. Now, however, swifter planes are routed by the center around slower craft and the landings take place in natural sequence.

Bad-Weather Approaches

Air traffic in weather not suitable for VFR (Visual Flight Rules) traffic is greatly aided by electronic navigation aids. Their use may perhaps be best illustrated by following the approach of a commercial airliner in inclement weather. In approaching the New York area, the plane stays under the jurisdiction of the Air Route Traffic Control Center until it is turned over to the Approach Controller in the control tower of the airport at which it is scheduled to land. The tower directs the plane down to the proper approach alitude for the instrument runway.

The instrument runway is equipped with two radio transmitters which guide the pilot to a safe landing. The first of these is called the localizer. Located on the far end of the runway, the localizer defines a vertical plane in space. The pilot is able to align himself with the center of the runway by observing a needle on one of the dials of his control panel. The dial also has a needle which indicates his position in relation to a radio beam defining the glide path, which is transmitted from a point slightly to the side of the instrument runway. This beam is perpendicular to the localizer's plane and slopes upward from the runway from a point about 1000 feet from the end at an angle of about three degrees with the horizontal. The glide path beam and the localizer intersect, the locus of their intersection being a straight line which defines the proper path of approach for incoming planes.

These radio aids to the pilot are supplemented by the approach light system. The lights extend about 3,000 feet from the end of the runway's center. A pilot flying on instruments, when completing his approach, can verify his position with respect to the runway by aligning his plane with the approach lights when he breaks through the overcast. Another cross-check on the pilot's alignment with the runway is provided by ground radar monitoring approaches. A traffic controller watching the monitor can warn the pilot by radio if he is not landing correctly. The pilot may, if conditions demand, make his landing entirely by guidance from the controller. This is not done, however, except on request of the pilot. This system is known as GCA (Ground-Controlled Approach).

GCA also aids departing aircraft. They are watched by radar as they climb from the airfield toward their designated flight path. Care is taken not to have the altitude levels of departing aircraft conflict with those being used by landing planes, and to provide for the proper spacing of aircraft using the same routes.

In spite of these aids to traffic control, air safety still poses a problem around busy metropolitan terminals. An average of about three thousand flights per day are handled in the New York area alone on Instrument Flight Rules.

FAA

Controllers seated at different positions in Idlewild Control Tower maintain separate control of ground and airborne traffic.

It is impossible to estimate the number of military, commercial, private and business planes in the vicinity which fly under Visual Flight Rules. There are fifteen times as many private and business craft alone than there are commercial airliners. All this adds up to crowded skyways and hazardous flying conditions. Air safety statistics report an average of four near-misses per day. Statistics make no mention of many more near-accidents that are never reported. More shocking still is the fact that during the period 1950 to 1956, there were eighty-one mid-air collisions in the United States, most of them occurring near terminal points. And yet, the most disastrous collision of that period took place over the Grand Canyon. This suggests that the job of air traffic control must extend beyond the region of the airports. At present it is estimated that for maximum safety no more than 3,000 airplanes should be aloft in the country at a given time. A step toward improved traffic control is being taken with the installation of long range radar, which scans an area 80 to 100 miles in radius. Eventually the coverage afforded by these stations will overlap, providing complete control, even for the remotest areas of the airways.

FAA

Radar aids air terminal traffic. At the left, Precision Approach Radar (PAR) checks the orientation of aircraft making instrument landings. At the right, Airport Surveillance Radar (ASR) keeps watch on airborne traffic.

Future Outlook

The next few years will bring tremendous advances in aviation with the introduction of jet planes on commercial flights. What new problems does this create for air traffic control, and what solutions are in view?

Probably within a decade, about a dozen major United States cities will have to ready their airports for the influx of jet traffic. It is not likely that many more cities will be affected, since jet transportation requires much fuel and equipment that makes it impractical for short runs. The cities that will be affected include some that already have problems in air traffic control. The advent of the jet age will mean not so much an increase in the number of planes handled as in the load of each plane. This will make it necessary for planes spending extra time in loading procedures and will create a problem of finding adequate "parking space" for the huge craft. Thus, the future will demand larger airports to handle jet traffic. At present, however, the number of landings and takeoffs per hour is limited more by the control system than by the actual size of the airport, except in a few extreme cases such as Chicago's Midway, the country's busiest airport, New York's La Guardia, and Washington's National Airport.

There are several solutions for increasing the capacity of the airports themselves in handling flights. One is the lengthening of existing runways to provide for the larger planes which will need more room for landings and takeoffs. Another is the construction of turnoffs. As soon as a plane lands and slows to the proper speed, it should be able to turn off the main runway on to a taxi ramp and permit immediate use of the runway by other planes. Without these auxiliary taxi areas and frequent turnoffs to them, runways must remain tied up while aircraft move along them to get to and from the terminal buildings.

Another solution for airports with extremely crowded conditions is the construction of runways parallel to those existing presently. This would permit two planes to make use of favorable wind conditions for landing and takeoff at the same time. If this construction would not prove adequate, the only alternative would be the construction of new airports in the extremely congested areas. Such construction, however, often meets with protest from neighboring communities and will probably prove unnecessary in most areas. At present, the best equipped airports can handle about forty-five landings and takeoffs per hour on instruments, and with improvements in their facilities, could probably handle as many as fifty.

Improvements in instrumentation may also help to ease the growing traffic jam. New electronic computers will take much of the burden of mathematical computations from the shoulders of the ground controllers.

One of the large hurdles yet to be overcome is the development of a practical device for avoiding mid-air collisions. It is a popular misconception that the radar with which many planes are equipped enables the pilot to spot an ap-

(Continued on Page 27)

MAGNETOHYDRODYNAMICS

by Jeremy Shapiro, ME '61

The Cornell Graduate School of Aeronautical Engineering has recently been investigating the subject of magneto-aerodynamics and its possible application to many fields, among them the field of missile development. A big problem facing the missile experts today is the tendency for the noses of intercontinental ballistic missiles to melt upon re-entering the earth's atmosphere.

The researchers here have worked on the principles behind a technique by which a magnetic field established in the nose can cause the flow of hot air to be diverted from the missile's surface. To the hot air, the nose would appear blunt. Theoretically, this branch of fluid mechanics is given the name "magnetohydrodynamics" and it deals with the "motion of electrically-conducting fluids in the presence of magnetic or electric fields."[1] The field unites the study of gas dynamics with the study of electromagnetism. Until recently, these two completely developed disciplines were independent, but the study of magnetohydrodynamics is bringing about their interrelation.

Re-entry Problem Solved

Upon re-entering the atmosphere, an intercontinental ballistic missile reaches speeds of Mach 15 to Mach 20. At speeds this high, the shock waves produced create regions of high pressure and very high temperature which heat the air that comes in contact with the nose of the missile. The friction with the increasingly dense atmosphere heats the rocket, and simultaneously decreases the acceleration. At a certain region of altitude, these combined effects produce a temperature maximum, sometimes as high as 20,000 F at the missile nose. Such temperatures are sufficient to cause failure of many structural materials. In this state, the molecules of the air become ionized, and it is this phenomenon that the scientists hope can be used in diverting the hot air. A properly oriented magnetic field would cause a force to be exerted on the ionized air stream and thereby prevent the hot air from contacting the surface. There would be produced a cooling layer between the surface and the air stream. The basic principle involved is a simple one; *F*orce equals *V*elocity (of a charged particle) cross *B* (the vector describing a magnetic field). the other alternatives that might supersede this solution to the re-entry problem are; first, the development of a

Avco Research Lab

One conceptual design of a re-entry vehicle would employ magnetohydrodynamic braking.

[1] W. R. Sears, Magnetohydrodynamics in Aeronautics. Presented at the American Rocket Society's Thirteenth Annual Meeting, Hotel Statler, New York, New York, November 17–21, 1958.

material that would withstand the high temperature; or, the use of a porous material through which coolant could be forced.

Magnetohydrodynamics to Regulate Power

Another interesting application of "magnetohydrodynamics" is the one scientists hope can solve the problem of excessive heating where the hot, expanding gases are nozzled in a rocket. The gases come in contact with the surface of the rocket at the "nozzle" and could cause melting at this point. Since the gases reach high temperatures in the tank and become ionized, the degree of ionization could be increased to sufficient magnitude by including sodium in the tank. Then, by placing a magnetic field at the desired section of the rocket, the gases could be "nozzled" by the field instead of the rocket shell. There would then exist a region of still, cooling air between the surface and the fast moving gases. By regulating the magnetic field, the shape of the "nozzle" could be regulated, and this would be a means of accelerating and decelerating the rocket.

Experimental Work at Cornell

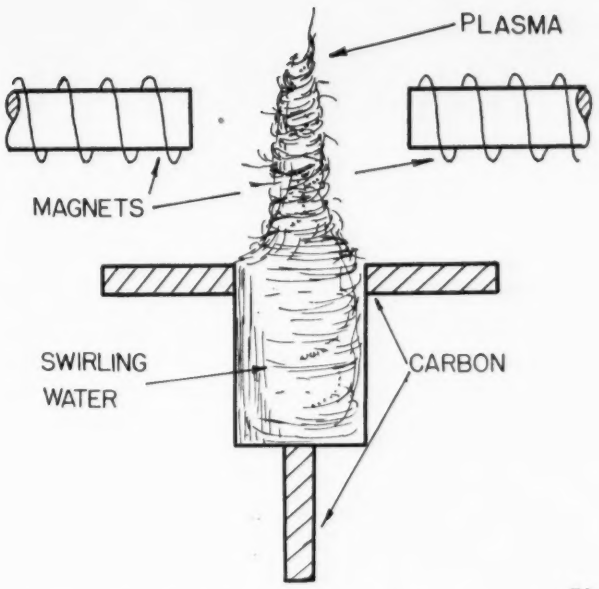
Experiments conducted at the aeronautical school were on an elementary level and were designed to determine the magnetic control possible on plasma, or ionized gas. A carbon arc with one pole in the shape of a ring was immersed in water and the arc formed. The water reached very high temperatures and an ionized jet of steam shot up through the ring into the open air. At this point, the jet was exposed to a magnetic field and it was found that the deflection could be satisfactorily controlled.

Low Thrust Accelerators

Private industry has also been investigating the possible applications of magnetohydrodynamics. In the AVCO Research Laboratory at Everett, Massachusetts, experimental low thrust electromagnetic accelerators have been developed. One design consists of two concentric cylinders with the space between their walls initially evacuated. The working gas is then admitted between the walls and subjected to a high voltage which breaks down the gas. It is then accelerated by a condenser bank to speeds sufficient to cause shock waves. High temperatures are produced ahead of the accelerated plasma. A magnetic field imposed in the axial direction creates a uniform distribution of the ionized gas and prevents it from touching the cylinder walls. A portion of the total matter enclosed is accelerated to high velocities and ejected. The gases that have been used in the experiment are hydrogen and deuterium.

Although velocities obtained have reached speeds of 500,000 miles per hour, the thrusts involved have been quite small. As a result, engines of this type would not be suitable for removing a body from the earth's gravitational field. However, in space these engines could be effective because small accelerations are feasible considering the large distances involved.

The satellites circling in low orbits need a small amount of thrust to overcome the atmospheric drag in order to keep a constant altitude. In addition, a small amount of thrust, such as that which is available from electromagnetic engines, would be sufficient to increase its altitude. Rocket ships going to the moon from large satellite stations could reach there very easily with these low thrusts. It appears that the electromagnetic engine may find wide application in relatively free space where gravitational forces are low.



Edward Loane

This experiment conducted at the Graduate School of Aeronautical Engineering provided definite evidence that magnetohydrodynamics can be used to control plasma.

Electromagnetic Control of Fusion Reactors

Magnetohydrodynamics may also be used in the control of fusion reactors. The temperature of the gases contained within the reactors are of such magnitude that they would vaporize the walls if they came into contact with them. Moreover, the gases must be maintained at high temperatures and any contact with the walls would cool the gas considerably. By magnetohydrodynamic control, the plasma could be kept in its boundaries without contact with the walls.

Chemical Combustion Engines

Scientists are attempting to apply magnetohydrodynamic principles to chemical combustion power generators. The electromagnetic effect would be used to control the reacting gases. This type of power generator would permit higher efficiencies than are possible in steam turbines. Turbines have wheels

(Continued on Page 27)

MAGNETIC TAPE CONTROL OF MACHINE TOOLS

by Peter V. B. Cornell, ME '59

In these days of computers and control, considerable work is being done on the problem of information storage or "memory" devices. However, such devices are more generally associated with computers than with controls. Only recently has the idea of a flexible storage been applied to machine tool controls. It appears that human effort might be saved with a machine tool having a flexible memory.

Here are some of the basic problems that arise in meeting the requirements of a practical memory control:

1) Preparing instructions so that the machine (or memory) can understand them.

2) Providing flexibility so that the machine can be quickly and cheaply programmed to do different jobs.

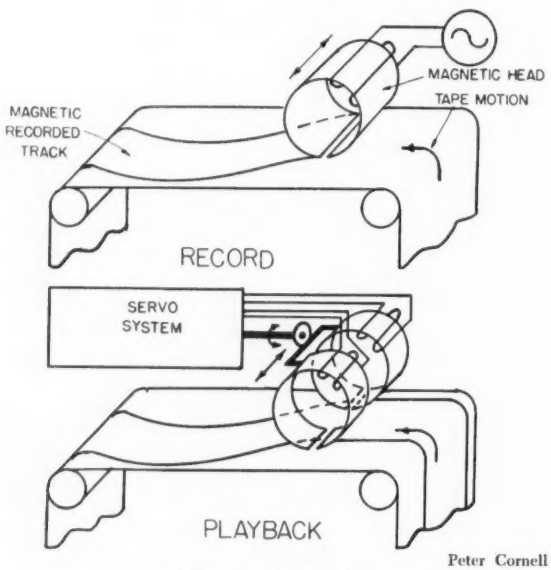
3) Providing a method so that the machine can remember what it has been told.

4) Providing a standard with which the device can measure distances with sufficient accuracy.

Type of storage device:

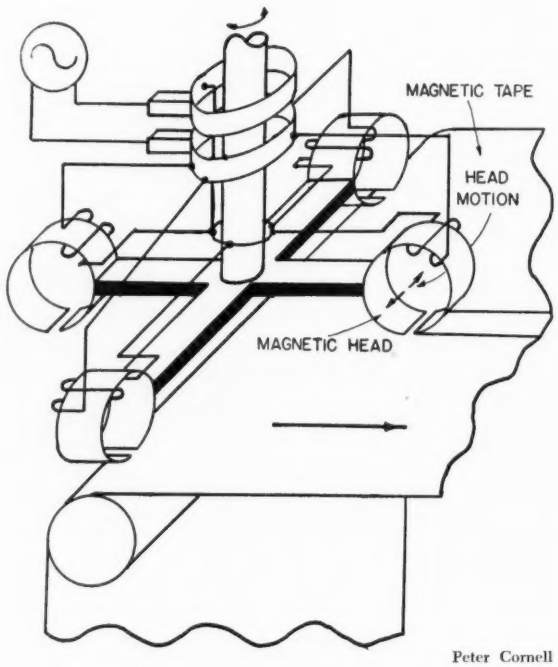
Computer storages may be classified into two categories. The "random access" storage is designed so that information can be drawn from any part of the entire storage with ease. This is a valuable feature for computing purposes but such memories are expensive and practically limited in size. Rapidly rotating magnetic drums and magnetic core memories are popular random access storage devices. By contrast, the "sequential" storage can practically present its information only in the order in which that information was recorded. Sequential storages are cheaper and they have a much larger practical capacity. Punched and magnetic tape memories fall into this category.

Sequential storage is best suited



Peter Cornell

Figure 1: Scheme two.



Peter Cornell

Figure 2: The "Merry-go-round" ⟶

for motion recording since the motions will be done in a regular sequence. The author has limited his investigation to magnetic tape because of its feature of erasability.

There are many ways that information can be recorded on magnetic tape. A little review of fundamentals will make the explanation of the systems clearer. Magnetic tape is a strip of thin flexible plastic which is coated on one side with a magnetic material. Now any part of this tape may be magnetized and it is possible to record information by magnetizing the tape as it is reeled past the recording point. The recording point might be a man waving a horseshoe magnet, a simple wire, or a fancy electromagnet. The usual configuration is a circular core, with a small gap, wound with wire. The gap is perpendicular to the direction of tape motion and rubs against the magnetic coating. The particular part of the tape that is between the two edges of the gap is magnetized by the current in the coil.

Digital computers generally use the binary number system so that each digit is either a zero or a one. This information can be recorded on magnetic tape by using a pulse of current in one direction for a zero and in the other direction for a one. When the tape is later passed over a similar ring (or head), corresponding pulses are induced in the coil and the information is played back.

Scheme one:

A simple method for recording motions would merely be to assign a linear value to a pulse (say 0.001 inch) and then count pulses. A simple analogy to this can be demonstrated with a typewriter. With pica type, each "pulse" is 0.1 inch; the space bar is a plus pulse and the back space key is a minus pulse. A practical version of this scheme has been developed by Micro-Path Inc. of Inglewood, California. It is marketed primarily as a control for small vertical milling machines. A disadvantage of the system is that it is incremental and any errors will accumulate until the machine is readjusted.

Digital vs. analog:

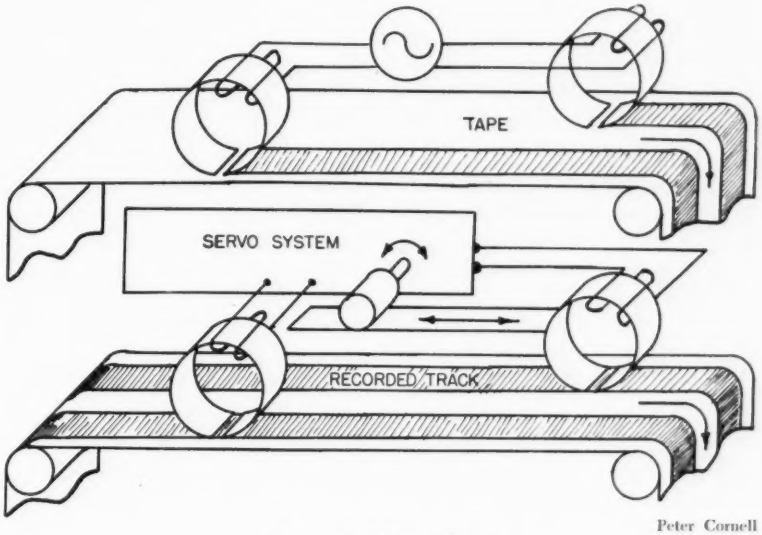
Because the resolution (length assigned to each pulse) of a digital scheme can be controlled, it is often preferred where accuracy is important. The alternative generally considered is an analog where the position to be recorded is represented by an amplitude or frequency. Such an analog would result in a very poor recorder because variations in the thickness of the oxide (the magnetic tape coating is generally an iron oxide) result in output voltages which are constantly varying as much as 10 per cent above and below the desired value. If an analog is to be used, it must be done in such a way that accuracy is maintained.

Scheme two:

Magnetic tape is manufactured to rather close tolerances. For example, the width of the tape can be held within 0.001 inch. Consider a blank tape one inch wide. We can take a recording head whose gap is, say, 0.050 inch long and mount it to record on the tape and simultaneously move across the face of the tape. As the tape moves by, the motions of the recording head are recorded by the track left by the head much as the stream of water from an ice truck "records" the distance between the ice truck and the curb by leaving a "track" of water on the street. This motion recording can be played back using two heads side by side which are made to straddle the recorded track. The voltage induced in each head is proportional to the amount that the head overlaps the track. The voltage outputs of the two heads will be equal when the heads are centered over the track and each is overlapping the track by the same amount. See figure 1.

Experiments by the author suggest that it is possible to trace a track in this manner using a servo device that responds to the difference in outputs of the two heads appropriately. It is feasible that trace accuracies of plus or minus 0.004 inch or better can be obtained.

This scheme can be directly applied to a machine tool if it is practical to use tape wide enough to accommodate the extreme swings of the recorded motions. An alternative to using wide tape would be a multiple head arrangement constructed so that as one head slides off the tape, another slides on providing continuous motion recording over a longer range with no loss of accuracy. Still another refinement is the head "merry-go-round" which has a rotational input and output and extends the range capacity without limit. See figure 2.



Peter Cornell

Figure 3: Scheme three

Scheme three:

It is also possible to record motions by moving the recording head along the length of the tape instead of across its width. With this method, two recording tracks are

required. The "reference" track is recorded by a stationary head and the "signal" track is recorded by a head which moves along the length of the tape. Both heads are energized by the same constant-voltage, constant-frequency alternating current. See figure 3. At the start of recording, the moving head is at some reference distance from the fixed head. From this point, motion of the signal head will change the relative phase of the two recorded tracks. During playback, the two tracks are read by heads identical to those used in recording. The alternating voltage outputs of these two read heads will be in phase only if the heads are separated by the same distance that separated the two record heads. The movable playback head is driven back and forth by a servo which senses the phase difference between the two signals and moves accordingly.

It is entirely possible, however, that the playback mechanism may skip an entire cycle and the playback motion would be in error by one wave length. (A wave length on the magnetic tape is equal to the tape speed in inches per second divided by the frequency in cycles per second.) The chances of a skip can be decreased by increasing the tape speed and/or decreasing the maximum speed of the recorded motions.

Another problem is that of tape stretch. Any stretching of the tape between recording and playback will show up as an error in the playback.

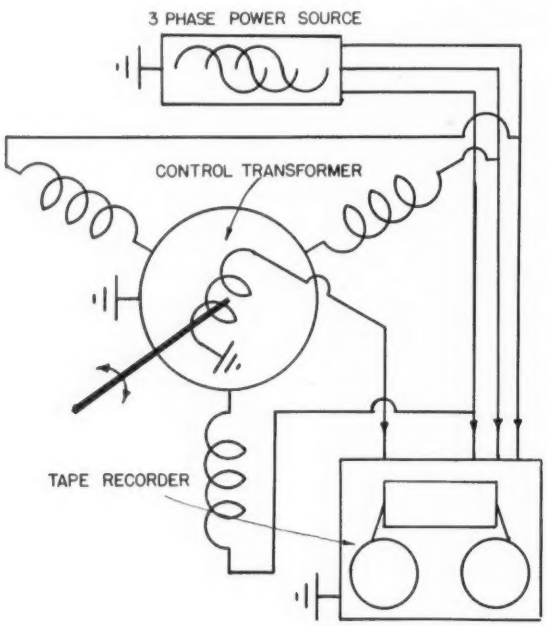
Possible refinements of this scheme include a head merry-go-round similar to the one described above and multiple frequency recording which will improve the accuracy at the expense of fancier electronics.

Scheme four:

Actually, this scheme is a refined version of scheme three except that the two heads are stationary and are placed directly in line both during record and playback. This eliminates the effects of tape stretch. Another difference is that the reference is a three-phase signal. In this method, the sensing device is an ordinary control transformer. The stator windings are energized with three-phase current so that the voltage induced in the rotor is constant in amplitude but varies in phase as the rotor turns. Both the three-phase reference and the rotor voltages are recorded. During playback, the reference is amplified and used to energize the stator windings of the control transformer and the servo compares the phase of the rotor voltage with that of the recorded signal voltage and rotates the control transformer rotor (also the output shaft) as necessary to keep the two voltages in phase. It is desirable to use the same linkages and control transformer for recording and playback as any nonlinearities of these devices which appear in the recording will be cancelled during the playback. See figures 4 and 5.

Applications:

In general, anywhere that there is repetition of physical human effort, there is a potential application for a motion recorder. In the area of machine tool controls, progress has only begun. For short runs, the operator would only have to make one piece by hand to "teach" the machine. From then on, the machine faithfully copies the motions of the operator and by speeding up the tape, the machine can be made to outperform its teacher. Additional tracks can be easily added to control the coolant, spindle and other accessory functions. Where accuracy is important, the tapes can be prepared in a drafting room away from the production floor. Tapes which are in demand can be duplicated and sent to factories in other cities. After the run is over, the tape can be erased and used for a new job; or it can be stored in a library for any length of time and used again the next time it is necessary to make more of that particular part.



← Figure 4: Scheme four record

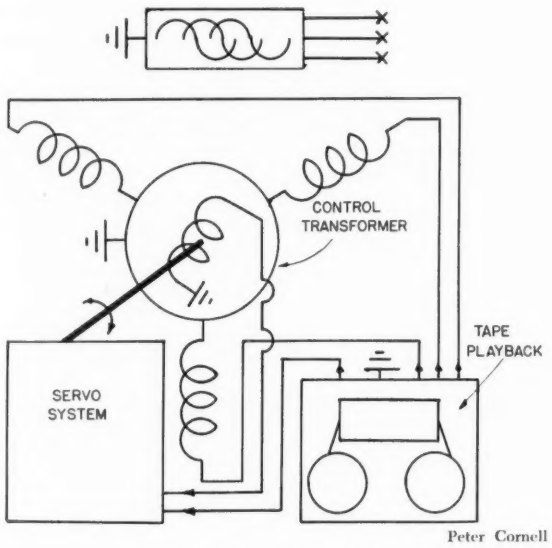


Figure 5: Scheme four playback

WHAT ARE TODAY'S ELECTRONIC BRAINS "THINKING" ABOUT?

by Charles E. Brau, EP '61

After performing the more routine tasks of launching rockets and figuring payrolls, some computers take time out for the lighter side of life and keep busy playing chess and composing music. Present machines are already at work designing circuitry for their successors, and a few people think computers may someday be taught to reproduce themselves directly!

Thirty years ago, who could have imagined the achievements of the electronic brains of today? The first giant computer was designed in the 1930's by Bell Laboratories as a by-product of dial telephone research. Only in 1944, did Harvard University and International Business Machines build the Mark I computer, the first widely publicized "brain." It could do months of work in minutes. A few years ago, the IBM 701 was 100,000 times as fast as a human accountant, and newer computers are many times faster!

Forecast Weather

As far back as 1952, Dr. John Von Neumann and Dr. Jules Charney of the Institute of Advanced Study at Princeton, New Jersey, together with Dr. R. Fjorloft, on leave from the Meteorological Institute, Oslo, Norway, developed a system of numerical weather forecasting for computers. The computer is given detailed information on present weather conditions and it mathematically predicts weather conditions for an hour later. On the basis of these predicted conditions it predicts what conditions will be an hour after that; so in twenty-four steps it predicts the weather twenty-four hours in advance. Unfortunately, the computer took twenty-four hours to do the computation, so it wasn't much help.[1] But the system was very accurate and Dr. Harry Wexler of the Weather Bureau and Mr. Philip Clapp of the Extended Forecast Section speeded the process up so that a five day forecast could be produced in 24 hours.[2]

In 1955, Dr. Lawrence Rosenfeld gave a computer all the data from 6,000 major league baseball games played over the previous five years, and instructed the machine in twenty strategies of betting. Before each game he added a few subtle points like who was the underdog, how many successive wins a team had had, etc. The computer digested the material and bet on the games. Doctor Rosenfeld could have won five times his initial investment had he bet throughout the 1955 season. He is now completing a computer to analyze the stock market for a large brokerage house. Previously a superficial check of 300 stocks kept all the skilled clerks of the firm busy, but the computer will do a detailed trend analysis of the entire market (2.000 stocks) in ten hours.[3] Imagine computers running the stock market, buying and selling among themselves!

Two years ago when a San Francisco thief attempted to rob a chain store he was surprised upon arrival to find the police waiting for him. Something had "ratted" on him: a computer had analyzed his method of operation and predicted that this particular store would be his next stop![4]

Translates Language

But these are all numerical and data processing uses. Electronic brains are able to do much cleverer things. In 1953 IBM scientists and Georgetown University linguists "programmed" (i.e., instructed) an IBM 701 computer to translate Russian into English. After the computer memorized a 250 word vocabulary, embracing politics, law, science, mathematics, and military affairs, and some simple rules of syntax and context it had no trouble translating, "A military court sentenced a sergeant to deprival of civil rights."[5] Russian word order is fairly close to English and the machine can choose the correct translation of roots with multiple meanings. The greatest remaining obstacles to accurate translating are idioms, which can be learned only by memorization. Principally due to the time it takes to sort and digest the punched cards fed it, the 701 takes several seconds to translate a sentence. Rental cost of the 701 is so high that using it as a translator is economically wasteful. However, the National Bureau of Standards and MIT are currently working on special machines for the job, and text translators should be forthcoming.[6]

A computer was used to compile the concordance of the Revised Standard Version of the Bible. One of the Biblical scholars was familiar enough with computers to come up with the idea and a computer completed the job in three years instead of the thirty it might otherwise have taken.[7]

Recently, computers have acquired the sensory functions, sight and hearing. Two machines have been developed which can scan and read a printed page, and MIT's Lincoln Laboratory has developed the TX-O, a device which can understand speech. Several

1. "Brains Forecast Weather," *Science News Letter,* March 22, 1952, p. 179.
2. "Brains get Weather Trial," *Science News Letter,* December 20, 1952, p. 395.
3. C. A. Carpenter, "Amazing New Uses for Robot Brains," *Science Digest,* February 1957, pp. 1–5.
4. *Ibid.,* pp. 1–5.
5. "Electronic Translator," *Time,* January 18, 1954, p. 82.
6. "Bilingual Machine," *Newsweek,* January 18, 1954, p. 83.
7. C. A. Carpenter, "Amazing New Uses for Robot Brains," *Science Digest,* February 1957, p. 1–5.

persons speak a word to the machine which "learns" it by analyzing the structure of the word and memorizing it with its meaning. The machine then compares words it hears with words it already knows in order to recognize what is being said. Significantly, none of the methods of comparison was reliable in itself, due to voice differences, but the machine could make reliable decisions on the basis of these comparisons.[8] In a few years, people will be able to talk to the computers and converse in many languages by means of them.

Computers as Composers

On August 9, 1956, the "Illiac Suite," for string quartet was first played publicly at the University of Illinois. It was actually composed by the university computer, Illiac, which was programmed by Professor Hiller, a composer and physical chemist and Leonard Isaacson, another physical chemist. The work has three movements in chronological order of the experiments with the machine. They range from a simple, "Presto-Andante-Allegro," to a highly complex third movement, "Allegro con brio." Composing time was fifteen minutes—less than the playing time or the time it took to transpose it from letters (A, G sharp, etc.) to notes on music paper.[9] Douglas Bolitho and Dr. Martin Klein have similarly programmed a Datatron to write popular music at the rate of 1,000 melodies per hour. The machine is capable of writing up to ten billion melodies at a sitting. Popular music is one of the most rigidly coded musical forms, with certain accepted rhythm patterns and note combinations. Rules for these are summed up for the Datatron in six basic melody requirements. Starting with a random number (like Beethoven's birthday) it quickly (ten seconds) produces 1,000 more random numbers and memorizes them. Each stands for a certain note. It then selects the first number (note), tests it for melodic properties and, if acceptable, prints the note on a sheet of paper. It then looks over the next notes, selecting the first that "makes music" and prints it on the sheet of paper. Printing out takes the most time, but meanwhile the rest of the computer is off on the next note. Mathematicians are now working on a machine which will develop its own rhythm patterns and write orchestrations.[10] Conceivably the music could be punched out on a roll of paper and fed directly into a player piano. Imagine having your own home composer to play, "extemporaneously," original music to suit your mood!

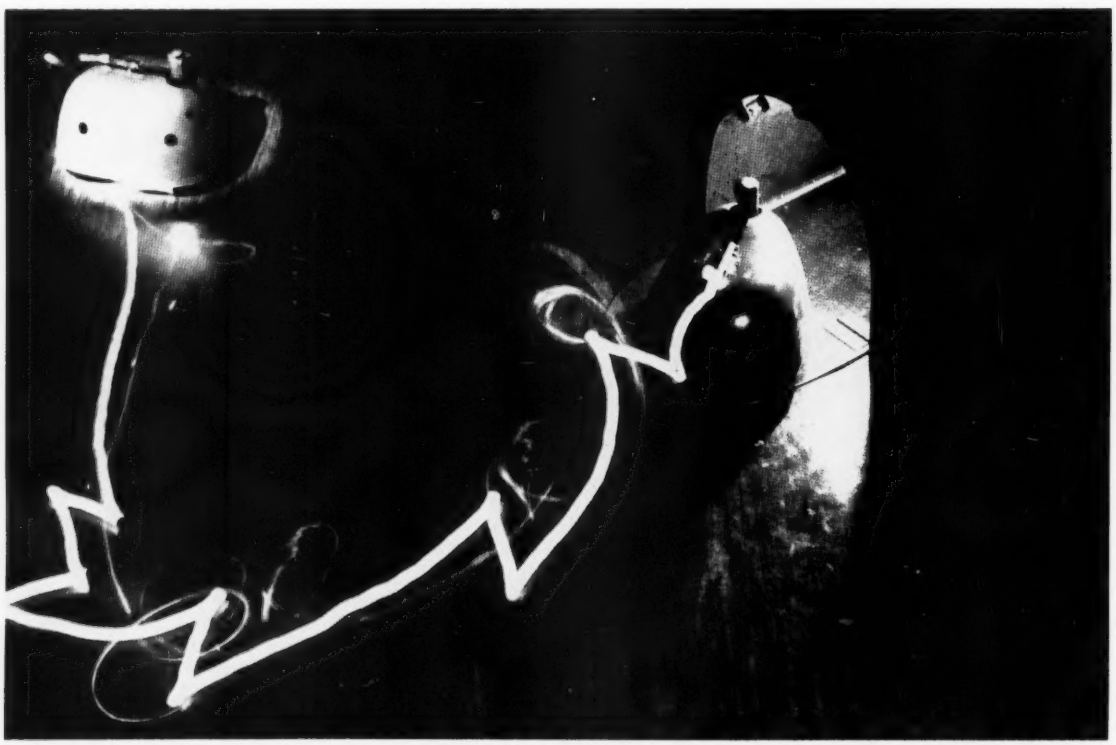
Computers Think and Play

Most sophisticated of today's computers are those which can reason and those which can play games of wit against human opponents. Dr. Rochester of IBM has programmed a computer which can prove geometrical theorems about as well as a high school sophomore. One unit analyzes the diagram for obvious relations, like

8. "Computer Taught to Hear," *Science News Letter*, May 17, 1958, p. 311.

9. "By the Numbers: Illiac Suite for String Quartet," *Musical America*, September 1956, p. 13.

10. B. W. Powell, "Machine Made Melodies," *Science Digest*, November 1956, pp. 29–30.



Similar to Theseus, the mechanical mouse is W. Grey Walter's *Machina Speculatrix*. This three wheeled "animal" responds to light and touch through two nerve cells. Each cell consists of a small electric motor, a resistor, a miniature tube, and a battery. It is capable of the basic modes of behavior of simple living creatures. It scurries about in small sweeping curves and can investigate one hundred square feet in an hour. *M. Speculatrix's* one positive tropism is its affinity to light of moderate intensity.

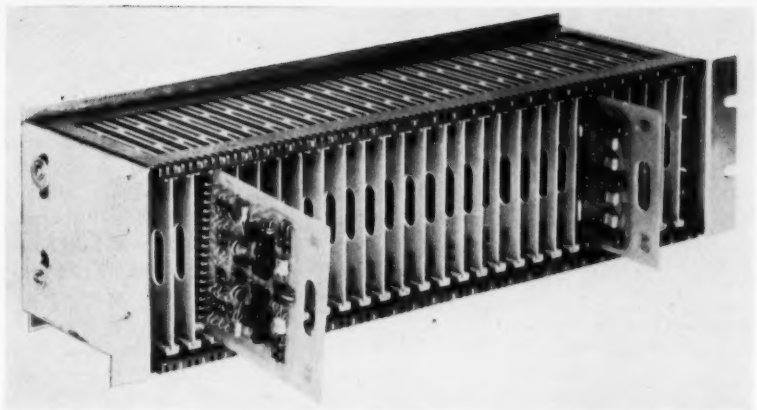
the number of triangles, equal lines, equal angles and so forth. Then the syntax unit looks up all the rules which might be useful, and the supervisory unit tries the rules one after another until the problem is solved.[11]

At games of wit, the computers play like humans. C. S. Strachey programmed a machine to play him at checkers. It fumbled around a bit in the opening moves, then came back with some very clever moves and almost won by the middle of the game. But a couple of poor moves toward the end lost the game for the computer.[12] At Grumman Aircraft Corporation, where the author worked last summer, the computer group programmed an IBM 704 to play checkers. It played fairly well, although good players could beat it.

Chess is much more interesting and complicated. An average game is forty moves by each player and there are about thirty choices for each move. This leads to 30^{80} or about 10^{120} possible games. If a machine were to play a million games a second, it would require 10^{108} years to play all the games. A machine cannot see all the games which could result from a move and figure out the absolute countermove, so a machine must reason out chess on human terms, looking a few moves ahead and planning strategy to get the best position.

Newell and Simon of Carnegie Institute of Technology have programmed a machine to play this way. It has beaten Newell but not Simon, who is considered a very good player. The machine bases its decisions on rules of thumb like "protect the king, control the center, maintain balance," and so on. The move selected is not necessarily the best, but it is the first which will not violate one of the rules. The machine can investigate ten moves ahead, but takes ten hours to ponder before moving.[13] Another machine, similarly programmed, can investigate three moves ahead in eight minutes. It selects its seven best moves, puts itself in its opponent's shoes and selects the seven best countermoves for each move. Eliminating its poorest moves, it chooses its best moves in response to its opponents expected countermoves and so on for three moves ahead. If its opponent cheats or makes a wrong move, the machine prints out, "Please check last move," and, win or lose, when the game is over the machine prints out the score and includes, "Thank you for an interesting game."[14]

Calculating machines have come a long way toward "thinking" in just a few years. Theseus, the mechanical mouse of Dr. Claud Shannon of Bell Laboratories, has a talent for finding "cheese." Placed anywhere in a maze, he will poke his way around until he finds it. Replaced anywhere in the maze, he will poke around until he comes to a place where he's been before, and then, with the aid of his memory, he'll run straight to the cheese. If the maze is changed or if the cheese is relocated, Theseus will poke around until he finds it again, and will memorize the new layout.[15] Thus he can solve by trial and error, remember a solution and apply it later, add new information and forget and relearn.[16] Reasoning is beyond him, but how many mice can reason?



Transistors which compose a circuit module for a random access memory system are mounted on glass-epoxy plates. These modules are then arranged in groups of twenty-seven to form a standard module assembly.

Just how closely can "brains" resemble the human brain? Right now the quantitative difference due to the million-fold greater complexity of the human brain is decreasing as computers become more complicated. Until recently, a computer with as many tubes as a brain has neurons would have required the Empire State Building to house it, Niagara Falls to power it and the Niagara River to cool it.[17] Now miniaturization is setting in. Transistors are gradually replacing tubes that have one hundred times greater size and power requirement. And a recently developed "memory" can store twenty million information "bits" per square foot, approaching the capacity of the brain.[18] It consists of a thin sheet of paper smeared with millions of microscopic capsules containing a light-sensitive dye. Information is read back with minute light beams. What's more, Dr. Carl Von Neumann pioneered theoretical computer logic and considered the problem of reproduction. He conceived an "animal" of conventional computer form capable of reproducing itself, given a "warehouse" of parts. Apparently, below a certain "threshold complexity" a computer can only create machines cruder than itself, and the "race" will degenerate and die out. Above this

11. "Electronic Machine Plays Chess," *Science News Letter*, June 7, 1958, p. 360.
12. D. O. Woodbury, "Could Robots Reproduce Themselves?" (excerpt from "Let ERMA Do It.") *Science Digest*, April 1957, pp. 84–88.
13. "Electronic Machine Plays Chess," *Science News Letter*, June 7, 1958, p. 360.
14. "Computer Versus Chess-Player," *Science American*, June 1958, pp. 96–98.
15. J. Lear, "Mechanical Mice With and Without Men," *Science Review*, January 22, 1955, p. 19.
16. "Machines That Think," *Readers Digest*, January 1954, pp. 143–146.
17. D. O. Woodbury, "Could Robots Reproduce Themselves," (excerpt from "Let ERMA Do It.") *Science Digest*, April 1957, pp. 84–88.
18. "Nearly Human Brain," *Newsweek*, November 25, 1957, p. 102.

threshold you can use your imagination.[19]

Create "Living Plants"

Looking to the future, E. F. Moore proposed a most fantastic scheme: artificial "living plants."[20] Imagine a machine a step above Von Neumann's capable of creating its own parts from natural elements, then assembling its image from built-in blueprints, just like a botanical plant. The seashore would be an ideal habitat: it can offer magnesium and other minerals from the sea, perhaps oil under it, wood and perhaps steel from the shore. The "plants" would migrate to gather materials where they could be found. With solar batteries they could get energy from the sun like real plants. They would merely reproduce themselves and multiply, and be harvested for the materials they were made of.

The problems involved in building the first "plant" will be in logic (largely solved by Von Neumann), electrical and mechanical engineering (more complicated forms of present engineering practice) and chemistry and chemical engineering. The latter two will present the most difficult problems remaining. If all the necessary chemistry and chemical engineering problems were immediately solvable and simple, the first "plant" could be built in five or ten years, for fifty to seventy-five million dollars.

Certainly a factory could be built to produce everything the "plants" might "grow," and at a considerably lower initial cost. But a factory has only a fixed output and over the years it depreciates and is discarded. But after the first "plant" is built it could multiply by itself and production would rise exponentially. Reproducing at one generation per year, in thirty years a million "plants" would be growing and multiplying. They would just continue this way subject to built-in controls, and after reproducing, the "plants" could migrate to the harvesting station to be harvested!

We can't yet build the artificial "plants" with organic processes using chlorophyll, amino acids, and starch, because not enough is known about organic chemistry. So the "plants" would use mechanical and inorganic processes, steel, gears, tubes, etc. We don't understand how genes control heredity and how hormones direct life functions. But we do understand enough electronics to do these things electrically. Unlike in a factory, efficient processes aren't needed. They can be simple, even crude in order to simplify the "plant," as long as they work. We still, despite what we know about theoretical genetics, cannot endow the machines with evolutionary abilities. Each plant will reproduce according to a set of blueprints. In a reply to Moore's proposal, D. A. Watkins points out that manufacturing tolerances would introduce successive errors, accumulating as slow evolution. Also, when the instructions for reproduction are imparted to the offspring, errors may occur from electrical noise in the circuits, producing mutants in the next generation. It's conceivable that offspring might eventually resemble man himself.[21] But we needn't worry, Moore points out.[22] A gradual accumulation of tolerance would be eliminated by using a primary standard of length, like the wave length of cadmium light, instead of transferring a standard of length from generation to generation. And as anyone who has worked with computers knows, "typographical" errors generally result in nonsense, which would probably be fatal to the "plant." Mutants might still survive, but mutations would spread slowly because the plants reproduce asexually. In asexual reproduction, the n^{th} generation has n ancestors, from which to inherit mutations, while in sexual reproduction the n^{th} generation has 2^n ancestors. In ten generations, this amounts to 2^{10} or 1024 sexual ancestors from which to inherit mutations, but only ten asexual ancestors. But for complete assurance, the plants could be designed so that after five hundred years, let us say, the entire population would return to the harvesting factory like lemmings. Any mutants failing to do this could be exterminated (by artificial "animals" if you like) and a new species could be started.

Future Importance

J. W. Carr III, of the University of Michigan, feels, "I have no doubt that electronic computers are going to have a greater impact on our society than atomic energy! In fifteen to twenty years, perhaps less, the electronic computer industry will be equal to the entire automotive industry."[23] In the light of what has been done with computers already, and with the theories advanced by Von Neumann, proposals like that of Mr. Moore can be made in complete seriousness. And when proposals like Mr. Moore's "plants" can be made seriously, it becomes clear that Mr. Carr's prophecy is just a sober evaluation of facts. If thirty years ago, no one could have imagined that we would have the computers we have today, who can say that he can imagine what computers will be doing thirty years from now?

19. D. O. Woodbury, "Could Robots Reproduce Themselves," (excerpt from "Let ERMA Do It.") *Science Digest*, April 1957, pp. 84–88.
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22. *Ibid.*, pp. 118–122.
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He's been on his way up from the day he started work

James C. Bishop got his B.S. in Electrical Engineering from the University of Illinois on June 23, 1953. On July 1, he went to work as a lineman in the Illinois Bell Telephone Company management training program. On July 2, he was "shinnying" up telephone poles.

And he's been "climbing" ever since. A planned rotational training program, interrupted by a stint in the Army, took Jim through virtually every phase of plant operations.

He was promoted to Station Installation Foreman in July, 1957. Then came more training at company expense—in human relations and other supervisory subjects—at Knox College.

Since early 1958, Jim has been Central Office Foreman in the Kedzie District of Chicago, which embraces about 51,000 telephone stations. He has 19 men reporting to him.

"I was hired as 'a candidate for management,'" he says. "I know I'll get the training and opportunity to keep moving ahead. How far I go is up to me. I can't ask for more than that."

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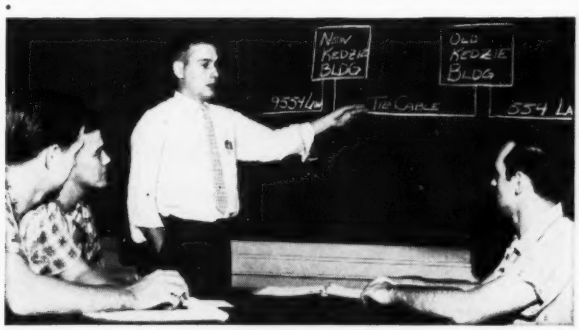

Jim Bishop holds training sessions regularly with his men. At left, he discusses cable routes in connection with the "cutover" of his office to dial service. At right, he and a frameman check a block connection on the main frame.

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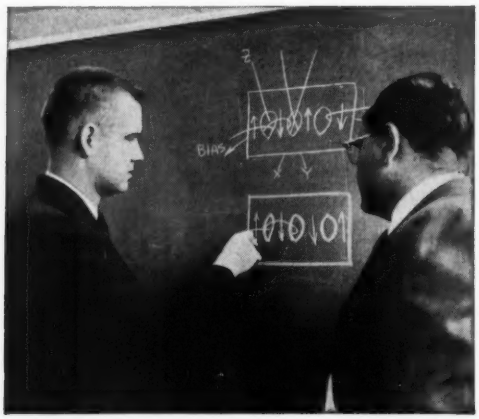
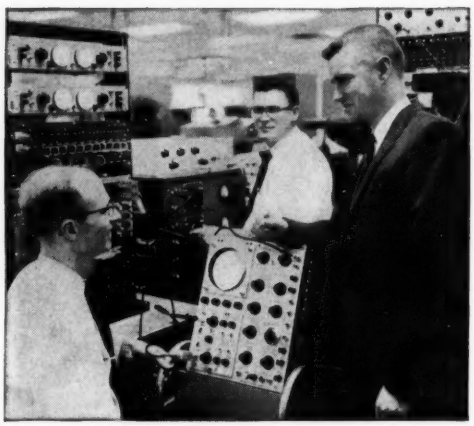


Computing time cut from six months to one day

"My job is to design and develop new, high-speed storage devices for a powerful new computer that will perform, in one day, operations requiring six months on present equipment," said Dick Booth as he began a typical day recently. A product development engineer at the IBM Laboratories in Poughkeepsie, N. Y., he started his morning with a conference on a product of great interest to him: a magnetic core storage device with a nondestructive read-out feature. For an hour, he discussed with circuit design engineers the logical devices needed for the register—such as magnetic core drivers and sense amplifiers. Should such devices not be available, the group would work on designs for new ones.

Dick Booth next met with members of the Magnetic Materials Group to establish specifications for the magnetic core memory elements to be used in the register. He also discussed with the group the development of equipment to test the memory elements. "This magnetic core register is based on an original idea of mine," he explained. "When you have a worthwhile idea, you will be given a free hand in proving it out, backed by IBM's resources — plus the assistance of skilled specialists."



Increasing responsibility

At 10:30, Dick Booth reviewed the status of the entire project with the two engineers, two technicians, and one logic designer who make up his team. "My present position is staff engineer," he explained. "It's the second promotion I've had since I joined IBM three years ago with a B.S.E.E. degree from the University of Illinois. I know that there are plenty of other opportunities to move ahead. Furthermore, parallel advancement opportunities exist for engineers in either engineering development or engineering management."

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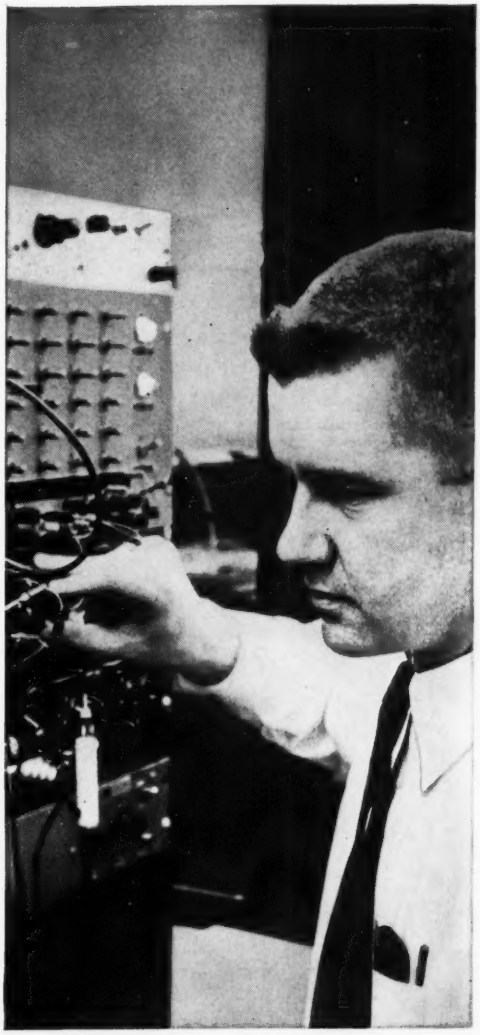

Preparing for the future

In the afternoon, Dick Booth went to the 704 Computing Center to supervise some complex precision computations. "You see how quickly the 704 arrives at the answers," he said. "The computer being developed is expected to multiply more than 500,000 fourteen-digit numbers a second and add them at the rate of one million a second. The computer may be used for design computations for reactors, as well as calculations of satellite behavior. Of course it should have hundreds of other applications."

At 3:30 P.M., Dick Booth attended a weekly class on Theoretical Physics that lasted until 5:00. Afterward, he commented, "You know, IBM offers excellent educational opportunities both in general education and for advanced degrees. One of the engineers in my group has just received his Master's degree from Syracuse University, after completing a postgraduate program given right here at the IBM Laboratory."

A chance to contribute

As he was leaving for the evening, he said, "Yes, I'd recommend an IBM career to any college graduate who wants to exercise his creative ability. IBM will appreciate his talent and he'll have the opportunity to work with specialists who are tops in their fields. I doubt that he'd be able to find a more sympathetic and stimulating atmosphere. Furthermore, he'll have the added incentive of contributing to vitally important projects . . . projects that will take him to the frontiers of knowledge in computer electronics."

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New Dean of Engineering:

PROFESSOR DALE R. CORSON

Dale R. Corson, professor and chairman of the department of physics has been named Dean of the College of Engineering, effective July 1. He will be the successor to Dean Hollister, who is retiring this June. His appointment was announced by President Malott after the approval of the Board of Trustees.

Professor Corson, whose background is that of a physicist, has had much professional and teaching experience with engineers. His appointment reflects Cornell's emphasis on teaching the basic sciences to the engineering student. Sound fundamental preparation prepares the engineer to face the vast array of new problems and developments which are constantly arising in each field. It also illustrates the gradual disappearance in many areas of a clear distinction between the work of the engineer and that of the scientist.

Professor Corson's career has ranged through the fields of basic scientific research, engineering development, education, and administration. His physics studies began with a B.A. received in 1934 from the College of Emporia in Kansas, and an M.A. received a year later from the University of Kansas. He continued his graduate work at Ohio State University and then went on to the University of California at Berkeley where he was awarded a Ph.D. in 1938.

One of his first notable achievements occurred in 1940 while working as a research fellow at Berkeley. By bombarding bismuth with alpha particles, he synthesized a new element, an unstable halogen named astatine. That same year he was appointed assistant professor of physics at the University of Missouri.

At the outset of the war Professor Corson joined the Radiation Laboratory at MIT. There he did research for the Air Force on radar for night fighters and night bombers. He later worked on the development of a radar system used to locate surfaced enemy submarines.

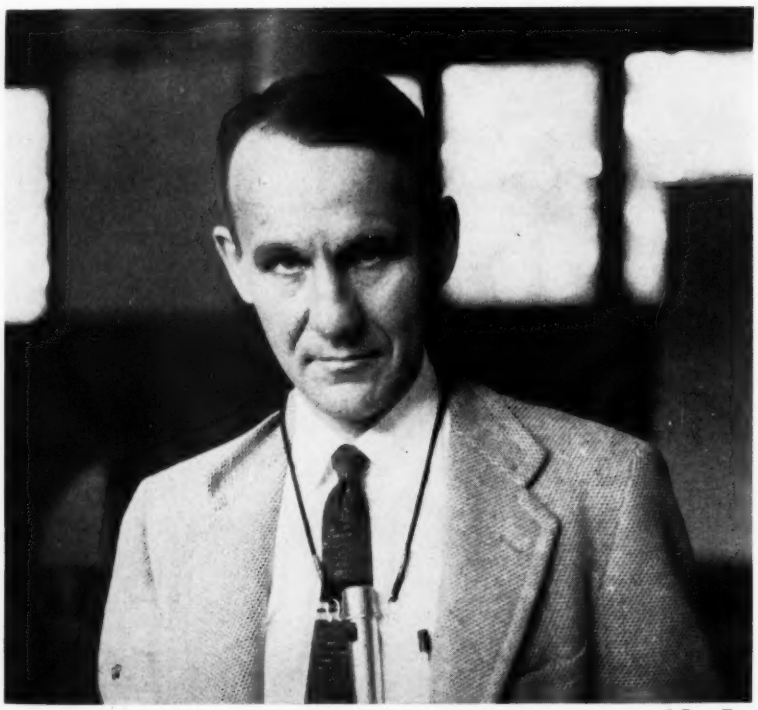
In 1943, Professor Corson returned to the University of Missouri as an associate professor while remaining as a technical advisor to the War Department. Two years later, he joined the staff of the Atomic Energy Commission's Los Alamos Scientific Laboratory. While there, he helped found the Sandia Laboratory in Albuquerque, New Mexico, which became the final engineering design station for atomic weapons.

Professor Corson came to Cornell in 1946 as an assistant professor. He became an associate professor in 1947 and a full professor in 1952. Three years ago, he was elected chairman of the Department of Physics, a position he has held ever since.

While at Cornell, Professor Corson has carried on some basic research involving the use of the synchrotron, a billion volt accelerator for study of subatomic particles. Most of the courses he has taught have been for upperclass physics and engineering physics students.

Several outstanding awards have been presented to Professor Corson during the course of his career. In 1948, he was the recipient of the Presidential Certificate of Merit for his work during and after the war. He has also been made a Fellow of the American Physical Society.

—by David Lamensdorf, EE '60



Jeffrey Frey

Professor Dale R. Corson

SAFETY IN THE SKIES

(Continued from Page 13)

proaching plane, and thus avoid accidents. Although the instrument does show the existence of cloud banks and other forms of "weather," it is not sensitive enough to detect anything so small as an approaching plane. One instrument developed for this purpose has proved too costly and bulky for practical use.

In the jet age, control over cross-country traffic will also be rigid. At present, the government issues sectional charts of the country, indicating airfields and other information useful to pilots. These charts also indicate certain restricted areas forbidden to aircraft without special permission. These restricted zones have been established for defense purposes and for special use by military aircraft. Before taking off, all commercial planes are required to file flight plans, and according to these, huge amounts of air space are reserved for them as they travel. While en route, the planes report their position over certain check points. In VFR weather, however, there is at present no altitude control. To relieve congestion on the busiest routes, the government constantly revises the size of existing air lanes and adds new routes. It is possible that sometime in the future, VFR flying may be totally abandoned in some areas, since the records have shown flight to be less hazardous under instrument checks. This development will not take place for many years though, since only a small number of aircraft have the expensive equipment necessary for instrument flight.

These facts, then, may give the reader some idea of situations in air traffic control, past, present, and future. The future of our national transportation system will depend in great measure upon what is done to overcome the problems of the jet age and perhaps, in the more distant future, of atomic air travel, and the safety hazards it will create.

MAGNETOHYDRODYNAMICS

(Continued from Page 15)

and blades that absorb heat and cool the hot gases, while a magnetohydrodynamic power generator would not. In addition, the temperatures possible within such a generator are of much greater magnitude.

The potential for magnetohydrodynamic devices appears enormous. However, the complex theory involved is difficult to formulate, and the applications cannot yet be rigorously developed. Moreover, their use in powering space vehicles presents several problems that are irreconcilable at this time. The magnets necessary to provide the required fields would be so large that their size and mass would prohibit them from use in flight. In addition, the "seeding"[2] techniques for making the gas sufficiently ionized have not yet been made practical.

[2] E. L. Resler, Jr., and W. R. Sears, The Prospects for Magneto-Aerodynamics. Journal of the Aeronautical Sciences, April, 1958, Volume 25, Number 4, page 243.

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Aero School's New Home:

GRUMMAN HALL

by Alden Speare, Jr., EP '63

The completion of Grumman Hall this spring gives Cornell the best housed aeronautical graduate school in the nation. The Cornell Graduate School of Aeronautical Engineering, which had been located in a temporary building on Forest Home Road, has recently moved to the modern facilities of Grumman Hall which provide excellent opportunities for aeronautics research.

Grumman Hall, which was completed this April, is a three story, blue-green building located behind Upson Hall. It provides facilities for both high-speed and low-speed flow problems with laboratories that have been constructed in such a way that they can be adapted to almost any kind of research in aeronautical engineering.

The building was donated by Leroy R. Grumman who graduated from the Sibley School of Mechanical Engineering in 1916 and is now a trustee of Cornell University. Mr. Grumman is founder and chairman of the board of Grumman Aircraft Engineering Corporation. He has received the Presidential Medal for Merit and several other honors for his work in aeronautical engineering. His gift of $500,000 for Grumman Hall is one of many gifts he has made to the university.

Grumman Hall Provides Many Improvements

The new aeronautical engineering building represents a considerable improvement over the temporary building on Forest Home Road which the school has been occupying for the last ten years. Besides offering better research facilities, it is adjacent to the other engineering buildings and provides a pleasanter working atmosphere.

Grumman Hall provides approximately 50 per cent more space than the old building. It has a large two-story wind tunnel laboratory which will accommodate a larger wind tunnel than the one in the old building. The first floor also contains a machine shop equipped to build precision research equipment, a machinery room, and the power supply for the wind tunnel.

The second floor houses an aerodynamics laboratory which contains, among other things, the "cascade" wind tunnel, a device for tests of compressor blading which could be operated in the old building only by removing a portion of the wall. Also on the second floor are a gasdynamics laboratory and an electronics room where specialized instruments can be made. The third floor houses the offices, the classrooms, and a conference room.

These facilities represent many improvements. The gasdynamics laboratory on the second floor can be operated in total darkness. A 3,000 pound per square inch air supply will soon be installed which will supply all the labs with dry air which can be reduced in pressure to serve many purposes. Hydrogen is also piped to all the laboratories from an explosion-proof gas storage room.

Richard Epstein

Grumman Hall, completed in April 1959, is the first permanent building for the Cornell Graduate School of Aeronautical Engineering. The gift of Leroy R. Grumman, '16, it is located on the new engineering quadrangle.

One of Finest Schools in Nation

The Cornell Graduate School of Aeronautical Engineering has existed since 1946 and has always been rated among the top three aeronautical graduate schools in the United States. It has received little notice on campus because of its small size. Having started with five faculty and twelve students, the school now has approximately thirty students. At first, the school was located in the Sibley Annex which was behind Franklin Hall but which has since been torn down. The move to Forest Home Road represented a vast improvement, but Grumman Hall is the first permanent and adequate quarters the school has had.

The school has always placed a strong emphasis on original research and provides the student with excellent facilities and expert

advice for his project work. The primary objective of the school is to produce engineers capable of carrying out research and development in aeronautical industries and institutions.

Besides offering excellent graduate courses, the school also has many courses that are open to undergraduates. Upperclassmen in the various engineering schools may elect aeronautics courses and may also do their projects at the School of Aeronautical Engineering. Prof. W. R. Sears, who is director of the school, states that the five year engineering graduates from Cornell that have taken electives in aeronautical engineering have a better aeronautics education than graduates from four year aeronautical engineering schools. "Moreover," he adds, "such students quite easily obtain their master's degrees after only one year whereas students who come from other schools need at least two years."

Much of the work done at Cornell is correlated with the work at the Cornell Aeronautical Laboratory at Buffalo and some of the graduate students get summer employment at C.A.L. The Cornell Aeronautical Laboratory is a self-supporting part of the University which performs research in the aero sciences. C.A.L. should not be confused with the graduate school on campus since all the instruction is carried on at Cornell.

Three Major Areas of Research

The research at the Cornell Graduate School of Aeronautical Engineering has been divided into three areas: gasdynamics, aerodynamics, and aeronautical structures. The research in these fields is supported by O.S.R. and O.N.R. contracts totaling approximately $180,000 per year.

The work in gasdynamics, which is the largest of the three groups, revolves around studies of fluids at high temperatures and high velocities. One of the phenomena that is observed under these conditions is that the fluid becomes ionized and can conduct electricity. Research in gasdynamics has practical applications to problems of rocket reentry into the earth's atmosphere.

The field of aerodynamics involves theoretical studies of boundary-layer problems and practical tests of power plant components such as the blading of compressors and turbines used in jet aircraft. Wind tunnel tests to determine the pressure at various turn angles of a blade are typical of the work done in aerodynamics.

The third area of aeronautical research at Cornell is involved with structure. Current research in this field is concerned with the aeroelastic properties of materials used in airplanes, missiles, and the like. The elastic deflection of these structures under aerodynamic loads affects these loads and a simultaneous study of both is required to solve the problem.

In all areas of research, the emphasis is placed on learning by original work and close association with the professors and the other graduate students. Conferences and seminars are often held to bring students and faculty together and an informal atmosphere prevails at all times.

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Faculty Profile

Dr. Theodore von Kármán

by David S. Kessler, ME '62

On the occasion of Theodore von Kármán's seventieth birthday, his friends and admirers presented him with four volumes containing the published accounts of papers which represented some fifty years of Dr. von Kármán's contributions to science and technology. In the introduction to the anniversary volumes, Hugh L. Dryden, director of the National Advisory Committee for Aeronautics, paid tribute to Dr. von Kármán. Mr. Dryden said, "His penetrating analysis of complex scientific and engineering problems to discern the important and essential elements, his success in subordinating mathematical technique to physical principles by the use of appropriate simple and rational approximate solutions, and his skill in the presentation of the results in clear and logical form have made von Kármán the outstanding aeronautical scientist of our generation." These words truly describe the effect Dr. von Kármán has had on twentieth century technology.

Cornell has been honored this term by the presence of this great scientist as Victor Emmanuel Visiting Professor in Engineering. In an interview, Dr. von Kármán discussed his own career and the future of aerodynamics, as well as the work he has been doing in the Cornell Graduate School of Aeronautical Engineering.

Von Kármán was born in Budapest in 1881, the son of intellectually endowed parents. The atmosphere of his home stimulated him in his early days and his interest in science developed rapidly. In 1902, he graduated with highest honors as a mechanical engineer from the Royal Technical University at Budapest. His first independent work concerned the resistance of materials and the buckling of columns.

It was not until 1908 that Dr. von Kármán became interested in aeronautics. He recalled how, at that time, he came into contact with the early aviators in Paris. Pioneers such as Henry Farna became close friends of the young Hungarian and von Kármán became interested in the aviators' problems. The maximum speeds of aircraft were then only of the order of forty-five miles per hour and a flight of more than forty miles was inconceivable.

At the University of Gottingen in 1909, Dr. von Kármán abandoned his early interest in airplanes and worked on problems of the dirigible. In 1911, he again became interested in airplanes. He assumed the directorship of the University of Aachen and, as a result, gained recognition by Kaiser Wilhelm of Germany. World War I interrupted his endeavors.

Dr. von Kármán chuckled as he recollected how, in the spring of 1914, he learned to fly. He agreed to give ground training to a group of Hungarian aviators in return for flight lessons. After ten lessons, he was allowed to make a solo flight and, while travelling at the "rapid speed" of twenty miles per hour, he made a nose dive into a potato field. Dazed but unhurt, the young soldier stumbled out of the field, only to be met by the politist in charge of the field. The latter had a summons and a fine for von Kármán along with the words, "Don't you know that in this time of the year you are forbidden to trespass in the potato field?"

Alan Male

Professor von Kármán

In spite of such humorous incidents, there was a war to be fought. Dr. von Kármán aided the Hungarian cause by pioneering synchronization of the machine gun with the propeller and designing a helicopter for artillery observation.

The war over, von Kármán returned to Aachen, which became a leading aeronautical center as a result of the work of its outstanding director. In 1926, the Guggenheim Foundation brought von Kármán to the United States for a lecture tour. He returned to Germany, but in 1930 the Guggenheim Foundation again beckoned. Dr. von Kármán was made the director of the Foundation's institute at California Institute of Technology.

Since that time his contributions to science has been innumerable. Von Kármán has excelled in the fields of applied mathematics, physics, strength of materials, theory of elasticity, turbulence, mechanics of fluids, aerodynamics of aircraft, and heat transfer. One of his most notable achievements concerned the mechanism of fluid resistance. He discovered a system of alternating vortices and, as a tribute, this system is known as the Kármán Vortex Street. Since 1949, he has been emeritus, and his activities have been confined to lectures and to work similar to that which he is now doing at Cornell.

Dr. von Kármán's purpose at Cornell is twofold. First, he has been giving a seminar on combustion, which he prefers to call aerothermochemistry. Second, he has been working with Professors Sears and Resler on the problems of magnetohydrodynamics. This relatively new field of research involves propulsion outside of our atmos-

phere. The three men are searching for ways to create and use ionized gas for propulsion in outer space. In addition, if any free time remains on his schedule, Dr. von Kármán would like to begin his memoirs.

In discussing the future Dr. von Kármán said that the next breakthrough in aerodynamics will probably be in the nuclear ram jet and nuclear rocket areas. Also, inertial guidance will soon be perfected. But the area in which the most work remains to be done he said, is that of safety. He envisions intense activity in this field. The guidance of aircraft will be centrally controlled from the tower. The pilot's only duty will be to check the instruments; the tower will guide the plane. Electronic computers capable of making a centrally controlled system work will soon be developed. Another major area of activity will be weather forecast and weather control. The present two-dimensional weather forecast is inadequate and satellites will aid in compiling broader forecasts.

Turning to the area of education and, particularly the education of a future space scientist, Dr. von Kármán feels that young American students are adequately technically minded and that they therefore do not need more technical education. Essentially, two things are lacking. First, more logical thinking is needed and second, more memorizing is needed. The first suggestion by von Kármán is self-explanatory. He explained the second by implying that thinking is slowed down if one does not have all the facts and formulas at his fingertips. In addition, the principle that one should learn what he likes and discard what he doesn't like is detrimental to a space-age education. A young man must learn everything, and engineers, in particular, must learn more physics and chemistry.

Dr. von Kármán compared the European and American systems of higher education. American universities have two weak points, he said. One weakness is that professors teach, for the most part, only the graduate courses, whereas in Europe these better-qualified people teach the fundamental courses. In fact, Dr. von Kármán finds that teaching the fundamentals is more inspiring for him. The other weakness is that American schools have too many examinations. The students are not given enough time to think and mull over the subject matter. Dr. von Kármán also found differences in rigidity of the curriculum. In the United States, the universities are stricter than the high schools, while the opposite is true in Europe. Cornell is to be praised, he said, because it is more in line with the European system.

Dr. von Kármán's life has paralleled the development of aerodynamics, but aerodynamics is just now flexing its muscles. Tremendous advances are yet to be made. Dr. von Kármán once said, "Perhaps the effort necessary to proceed from the present-day long-range, high-altitude rocket to a manned space rocket is no more than the effort which led from the Wright brothers' airplane of 1903 to today's supersonic aircraft. This progress was achieved through the thinking and striving of two generations of practical engineers and theoretical scientists."

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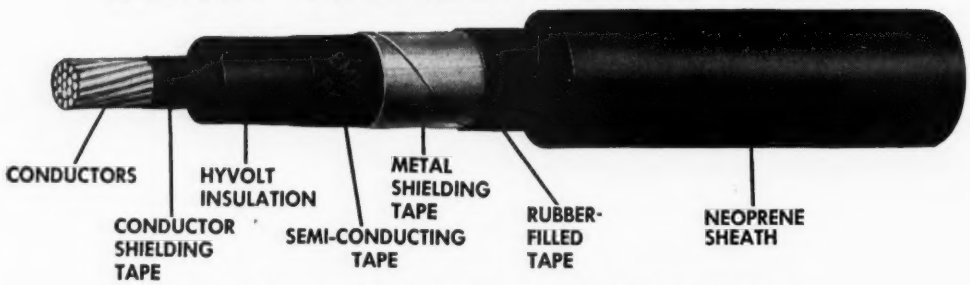

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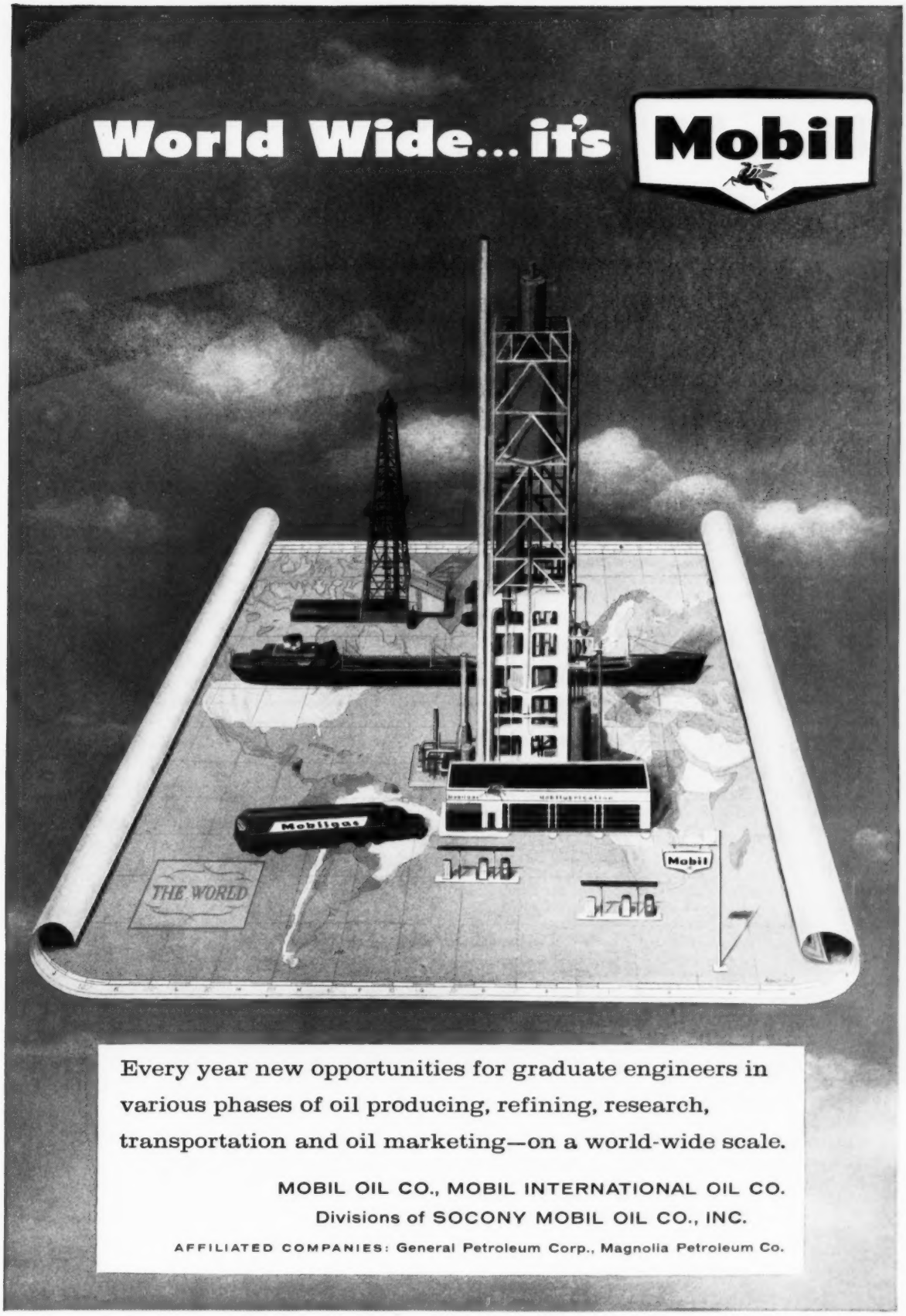

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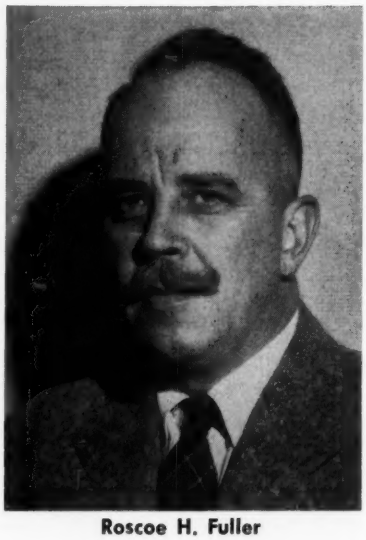


Roscoe H. Fuller

"The objects of this Society are to promote the welfare of the College of Engineering at Cornell University, its graduates and former students, and to establish closer relationship between the College and its alumni."

THE PRESIDENT'S LETTER—

As the end of the school year approaches, a new crop of graduates will start out on the long and involved process of earning a living, each with the normal hope of advancement in his chosen field, and each with the normal crop of ideas and ambitions. Earning a living, whatever one's field, involves getting along with people.

About the most succinct advice I have seen on this subject comes from the pen of Carl M. Beach, a prominent executive in the machine tool industry, who issued these suggestions for the benefit of the employees in his company:

TEAMWORK

Efficient, intelligent, enthusiastic teamwork is not only important but vitally necessary to the successful progress of every man or woman who works—whether he be a file clerk, factory worker, plant superintendent or president.

Teamwork makes our work a pleasure—not a bore.

It makes happy work and profitable work from which we go home with a feeling of accomplishment.

1. People will generally do most anything for you if they like you. Therefore, cultivate people. Show a sincere, friendly interest in them, their work and their problems.
2. Remember that our customers are our real bosses. They will continue to do business with us only so long as they think they receive the quality and service owed them.
3. We shouldn't worry about who gets the credit for a good job as long as the team and company benefit. Remember that every player on a football team is important, not just the one who scores. Unless each and every player does his part, the team does not win. Whatever your job may be it is important to the company team.
4. Never fail to take the blame when the fault is yours. One of the best ways to develop strong team spirit is to make it clear that no one will be blamed for another's mistakes.
5. Keep it simple. The "hard way" makes it difficult for everyone on the team.
6. Cooperate. Cooperation is teamwork in action.
7. Avoid gossip. Idle gossip is the natural enemy of effective teamwork.
8. Have a constructive attitude. A negative, critical attitude dulls the enthusiasm and spirit of all who witness it. A positive, helpful attitude inspires others to higher interest and effort.
9. Time your work to fit the next man's or department's schedule so that things flow smoothly. Did you ever look inside your watch? It keeps time as long as every part does its job—but if one wheel stops—the watch stops.
10. Don't be afraid to **ask** questions if you don't know. It is better to be right than sorry.
11. Answer questions—and cheerfully. Help the other fellow and make it easy for him to ask questions.
12. When you give an order to a worker be sure to accompany it with the necessary instructions for its proper execution. Then forget it. Don't look over his shoulder as though you doubt his ability to carry it out.
13. Show enthusiasm and feel it. If it is real you will be surprised how contagious it becomes.
14. Get it done. When a thing has to be done—do it. Don't just talk about it.
15. Try first to figure it out for yourself. Instead of asking your superior "What shall I do about this?"—give it careful thought and when you think you have the answer say "I think this should be done this way—do you approve?"
16. Establish a reputation for fairness. Let everyone on your team know that they can count on what you say—that you will play no favorites and will always carry your share of the load.
17. Welcome responsibility—don't dodge it. When one person on a team is asked to shoulder more responsibility than another it is a compliment to that person.
18. Keep a little black book—of ideas, suggestions, mistakes you have made and want to overcome, things you've learned, things you want to do for self-improvement.
19. Give encouragement freely when deserved.
20. Give full measure and carry your weight.
21. Say "we" more often than "I"—that's the team way.
22. Concentrate on **your** job. Let the other fellow do his own without your help **forced** on him.
23. Hear the other fellow's point of view. You may not agree with him but he is entitled to be heard. That's the way ideas are born.
24. Avoid waste. Wasteful practices make a big dent in profits and in profit sharing.
25. Never stop learning. We cannot get ahead by standing still and keeping our minds closed to new ideas.
26. People are human beings. They have hearts and minds and feelings and no two are alike. Good teamwork calls for understanding on the part of each of us.
27. Do your work each day as though you were in business for yourself.

Good thoughts here!

ROSCOE H. FULLER

ALUMNI ENGINEERS

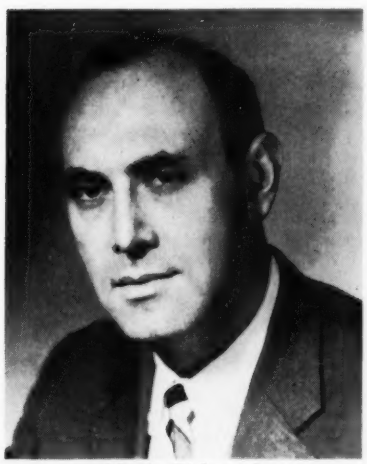
Edited by
J. F. Thomas, ME '63

John Munns, M.E. '14, has retired from National Steel Corporation. Mr. Munns started his career with Bethlehem Steel before serving as a lieutenant in the Navy. During his naval career, he was decorated for heroic rescue action. Mr. Munns then joined Continental Can, where he became manager of its Chicago operations. He joined National Steel in 1935 to establish at the Weirton division the first quality control department in the steel industry. In 1954, he became vice president of research and quality control for National, senior vice president in 1955, and executive vice president in 1956.

Martin Richmond, B.S.A.E. '48, has been promoted to vice president of the Consumer Products Division of Emerson Radio and Phonograph Corporation. The promotion was announced by the president of the corporation, Benjamin Abrams.

Mr. Richmond is a member of the Cornell Society of Engineers and the American Institute of Industrial Engineers where he has lectured on Work Measurement Techniques. He is also a founder of Work Factor Associates.

Mr. Richmond joined Emerson as an industrial engineer in 1949 and by 1955 he had advanced to the position of chief methods and standards engineer. He became staff assistant to the vice president of engineering and manufacturing in 1956. He was then promoted to the position of production manager in 1957 and to that of works manager less than a year before he assumed his present job as a vice president.



Martin Richmond

Robert N. D'heedene, E.P. '57, has been awarded a graduate fellowship from Bell Telephone Laboratories. He is a member of Tau Beta Pi and had received a National Science Foundation Fellowship for 1957-58. He is presently attending Harvard University where he is pursuing his specialty of applied mathematics.

George L. Weissenburger, M.E. '24, was saluted recently in Iron Age. He is president of Keokuk Electro-Metals Co.; has been a member of the Iowa Development Commission, Iowa Manufacturers' Association, Quad-Cities Post of the American Ordnance Association, and a trustee of Parsons College. He is also a regional vice-president of the National Association of Manufacturers. His further list of activities includes local business groups, service groups, and county politics.

Dr. John L. Carter, Jr., Ph.D. '52, has been appointed Supervisor of Theoretical Physics at General Electric Company's Hanford Laboratories, Richland, Washington. Hanford Laboratories is part of the Hanford atomic works.

Dr. Carter will supervise research work in the fields of reactor physics and solid state physics.

Since joining the company he has been employed as a physicist at its plants in West Lynn, Massachusetts, and Richland.

Dan E. Westervelt, C.E. '40, has been appointed to the sales engineering staff of the Montebello fabricating division plant of Kaiser Steel.

Before joining the Kaiser organization in 1957, Mr. Westervelt was engaged in government work, serving for two years as chief supply service director for the United Nations Korean Reconstruction Agency and later as consultant for the General Service Administration. Prior to his appointment at Kaiser Steel's Montebello plant, he was government projects manager for Kaiser Engineers Division, Henry J. Kaiser Company.

A native of New Jersey, Mr. Westervelt attended Culver Military Academy. He is a member of the National Society of Professional Engineers, American Society of Civil Engineers and the American Society of Military Engineers.

William R. Heath, M.E. '22, was recently promoted from executive vice president to president of the Buffalo Forge Company. Mr. Heath joined Buffalo Forge immediately following graduation. A short time later, he became chief engineer and rose quickly through a series of promotions to the presidency.

Warner D. Orvis, M.E. '07, was recently presented an anniversary tray marking his forty-five years of service as a trustee of Manhattan Savings Bank. He is senior partner in Orvis Bros., brokers.

Horace H. Chandler, M.E. '32, has been appointed manager of the Texas Company (Iran), Ltd., with offices in London. He was formerly assistant manager and has been with Texaco for twenty-six years, mainly in the refining department. He became superintendent of the company's Eagle Point Works in 1955 and in 1957 was assigned to the London offices.

Alumni News

Horace H. Chandler

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COLLEGE NEWS

Edited by A. Speare, Jr., EP '63

THEODORE VON KARMAN SPEAKS AT CORNELL ENGINEER BANQUET

The CORNELL ENGINEER held its annual banquet on April 12 at the Clinton House. The highlight of the program was an after-dinner talk by Theodore von Kármán who is visiting Cornell this term as Victor Emmanuel Professor in Engineering.

Toastmaster was the retiring editor-in-chief, John M. Walsh III, who announced the retiring board members and the incoming publication board. Alan Rosenthal, the incoming editor-in-chief, then took the floor to present the retiring editor-in-chief with a gift for his services and to present the retiring assistant business manager, Sidney Turkish, with a gift for his outstanding contribution to the CORNELL ENGINEER during his five years on the staff.

Solomon C. Hollister, dean of the College of Engineering, then rose to introduce the guest speaker, Dr. von Kármán. Dr. von Kármán is one of the world's leading authorities in the field of aerodynamics and has been at Cornell since the start of the spring term.

Dr. von Kármán spoke about engineering and stressed the importance of (1) the history of scientific developments and (2) a substantial knowledge of the fundamentals. He said that it is necessary to understand the way in which discoveries were made in the past in order to be able to make new discoveries. He commended the CORNELL ENGINEER for the many historical articles it has published.

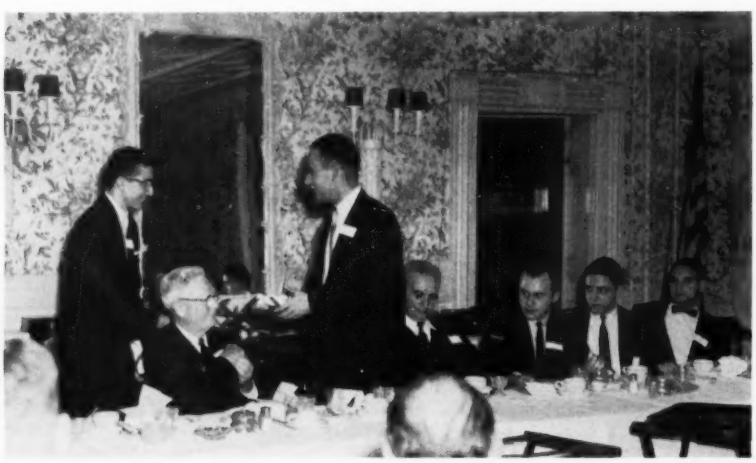
He also stressed a knowledge of fundamentals, pointing up the fact that a broad background is necessary to the development of new fields and that up to now developments have been made mostly by physicists and mathematicians. He commended the Cornell College of Engineering on its efforts to provide many basic physics, chemistry, and math courses in the engineering curriculum.

CORNELL PLANNERS HOLD URBAN TRANSPORTATION CONFERENCE

The Second Annual Spring Conference of the Organization of Cornell Planners was held at the University on March 20–21 in Statler Hall. Goal of the conference was, through the combined efforts of the many professional experts in transportation and land-use planning who attended, to contribute to knowledge in the field of urban transportation which is one of the major problems of present-day urban development.

The program of the conference was organized entirely by students of the Planners, a group of graduate students in architecture. The program featured a lecture on "Metropolitan Transportation" by Roger L. Creighton, assistant director of research and planning of the Chicago Area Transportation Study.

Several panel discussions were also presented. The first of these was "Transportation as a Builder of Cities," given by Prof. Serge Chermayef of the Harvard Graduate School of Architecture; John G. B. Hutchens, professor of business history and transportation at Cornell; and Dean Thomas W. Mackesey, of the Cornell College of Architecture. The series' second discussion, "Trends in Urban Transportation," was presented by David L. Mackie of the Eastern Railroad Presidents' Conference; D. Grant Mickle of the Automotive Safety Foundation; Walter Rainville of the American Transit Association; and Wilbur Smith, transportation consultant. Participants in the third panel, "Framework for Planning—Search for a Policy," included Creighton; Richard A. Miller, associate editor of *Architectural Forum;* and David R. Levin of the Bureau of Public Roads. Speaking in the last panel discussion, "Land-Use Planning in an age of Changing Transportation Patterns," were John T. Howard of the Massachusetts Institute of Technology; T. Ledyard Blakeman, planning advisor; Frederick P. Clark, planning consultant; and Carl Feiss, planning and urban renewal consultant.



Alan Male

Retiring Editor-in-Chief Jack Walsh receives a gift from his successor, Alan Rosenthal, on behalf of the staff of the Cornell Engineer.

JOHN TILTON RETIRES FROM ARCH. COLLEGE

The end of the spring term will see the loss of one of Cornell University's finest men. The retirement of Professor John Tilton of the College of Architecture has recently been announced by the college.

An alumnus of Cornell, Professor Tilton received the B.Arch. degree in 1913 and the M.Arch. degree in 1914. Before joining the faculty of the college in 1932, he was a partner in the Chicago architectural firm of Furst, Armstrong, and Tilton, a position he retained for several years following his coming to Cornell.

Professor Tilton served as acting dean of the College of Architecture in 1937 and 1938. He has also

served as assistant dean and as secretary of the College. At the present time, Professor Tilton teaches working drawings, mechanical equipment, and freshman descriptive geometry in the college and is one of the outstanding men in his field. At last year's annual meeting of the Association of Collegiate Schools of Architecture, Professor Tilton was presented with one of only three Certificates of Merit given to Professors of Architecture in the United States in recognition of long years of effective teaching.

THREE CORNELL AERO STUDENTS WIN IAS AWARDS FOR PAPERS

Three Cornell students received prizes for their papers at the Northeastern Student Conference of the Institute of the Aeronautical Sciences which was held at Cornell on April 4. The conference included the presentation of papers in the morning and afternoon and a banquet in the evening at which Dr. Theodore von Kármán was the guest speaker.

The winners announced at the banquet were: in the undergraduate group, Joseph Pratt of Virginia Polytechnic Institute and Albert George of Princeton; in the masters group, Alister Frazer of Brown and John Moran of Cornell; and in the doctorate group, William Rae and Edmund Lary, both from Cornell. The papers were judged on the basis of presentation and content. The winners received cash prizes of $100 and $75 for first and second place. The first place winners also will have their papers published along with all the other IAS Regional Student Conference winners in a book. One top winner is then chosen from each group at the annual IAS convention the following January to receive the Minta Martin Award. Herman Mark, Ph.D. '57 won this award in the graduate division in 1957.

At the banquet held in the Statler, Dr. von Kármán, who is the Victor Emanuel Visiting Professor in Engineering at Cornell this term, spoke on "Engineering Education in Our Age." He stated that it is not sufficient for an engineering education to be a transfer of the previous generations' experience in a field. It must also include or indeed emphasize the fundamentals of science in any field of interest. As an example, he presented the case of the modern aerodynamicist who must be well versed in physics, thermodynamics, chemistry, electromagnetic theory and several other fields.

Dr. von Kármán also gave some advice to the young aeronautical engineers, telling them not to jump on the bandwagon of space and treat it as the sole area of interest in their field in modern times, but rather to treat it as an extension of travel in the air. Man will still be using airplanes for a long time to come and there are many problems still to be solved in that field.

The Cornell student chapter of the IAS is unusual in that it is composed almost entirely of graduate rather than undergraduate students. This is principally due to the fact that the School of Aeronautical Engineering is for graduate study only.

PROF. SACK RETURNS FROM EUROPEAN TRIP

Henri S. Sack, professor of Engineering Physics, has recently returned to campus after a trip to Europe. Prof. Sack was in Europe from August until March and did research and gave many lectures in the field of solid state physics.

Prof. Sack spent part of his time in Belgium where he did research on radiation damage in solids at the Belgium Atomic Energy Center at Roe-Dont near Brussels. He also gave approximately thirty-six lectures that were sponsored by the Advisory Group on Aeronautical Research and Development, which is a division of NATO. Most of these lectures were given at universities, government agencies, and industries in the NATO countries of Belgium, Holland, France, Germany, Norway, and Great Britain. Dr. Sack also exchanged much information with the NATO countries and helped to publicize the work that is being done in America.

Ken Workman

Professor Sack

Throughout Europe, Prof. Sack noticed that research facilities were being built up and that firms were having difficulty getting qualified scientists and engineers to do research, but that the situation was improving. He noticed everywhere that there was a growing awareness of the importance of materials in technical development.

AEC-ASEE TO OFFER SUMMER NUCLEAR ENERGY INSTITUTE

The Atomic Energy Commission and the American Society of Engineering Education will jointly sponsor an Institute on Nuclear Energy at Cornell University this summer. The Department of Engineering Physics will be responsible for conducting the program and Professor T. R. Cuykendall, head of the Engineering Physics Department, will be the director.

The summer Institute will give thirty engineering and science college teachers from all over the nation an opportunity to learn the broad concepts of reactor problems with the hope that they will then be able to aid their institutions in planning nuclear programs and in incorporating pertinent material into present courses. A similar institute is also being held at North Carolina State College in Raleigh, N.C. Both institutes will run from June 22 to August 14 and will consist of a balanced program of lectures and laboratory experiments.

The mornings will be taken up by lectures covering the fields of nuclear physics, reactor physics, nuclear metallurgy and materials, chemical processing, radiochemistry, instrumentation, radiation damage and hazards, health physics, and isotope separation. There will be about sixty-two of these lectures.

Since nuclear technology is an experimental science, laboratory experiments relating to the lecture topics will be performed four afternoons a week to supplement the lecture material. These experiments will include the determination of half-lives, the transmission and back-scattering of neutrons, gamma spectroscopy, uranium mi-

crostructure, absolute flux measurement, sub-critical reactor parameters, and reactor kinetics with an electronic simulator. There will also be a tour of the Cornell 1-MEV Synchrotron.

Besides the regular lecture and laboratory program, there will be several lectures on topics in nuclear engineering given by invited guests who are authorities in this field. Last year these lectures covered such topics as the gas cooled reactor, the molten salt reactor, the liquid metal–fuel reactor, and the use of critical assemblies in reactor design.

The last ten days of the Institute will be spent at the Brookhaven National Laboratory on Long Island where there will be lectures on special topics, tours of the facilities, and laboratory experiments. Last year's program included tours of the health physics operation, medical reactor facilities, the hot laboratory, and the cosmotron, as well as an observation of the graphite reactor shut-down and start-up. A similar program for those at North Carolina will be held at Oak Ridge.

C. A. COULSON SPEAKS AT BAKER LECTURE SERIES

C. A. Coulson, one of Britain's leading scientists, discussed "The Size and Shape of Molecules" before audiences at Cornell University in the annual series of Baker lectures this spring. The lecture series lasted from Feb. 17 to April 30 and Professor Coulson spoke every Tuesday and Thursday during that time.

Prof. Coulson is Rouse Ball Professor of Mathematics at Oxford University and a fellow of Wadham College at Oxford. He received his M.A. and Ph.D. degrees from Cambridge University and has been awarded a Doctor of Science degree from St. Andrews University. He is a fellow of the Royal Society, the Royal Society of Edinburgh, and the Institute of Physics.

Prof. Coulson is the author of three scientific textbooks and about two hundred research papers, chiefly in the fields of quantum theory and theoretical chemistry. He has also written many articles on the relation between science and religion.

FOUR BOARD MEMBERS OF THE CORNELL ENGINEER RETIRE

Some of the staff members of the CORNELL ENGINEER will graduate in June. Since they have contributed so much to the success of the magazine over the past few years the ENGINEER is pleased to introduce the graduating staff members to the readers.

John Walsh, the retiring editor-in-chief, rose through the offices of associate editor and managing editor after joining the ENGINEER as a freshman. A student in the School of Chemical Engineering, Jack is a member of the American Institute of Chemical Engineers and was President of Pros-Ops, the chemical engineering honorary, besides being in Pi Delta Epsilon, the journalism honorary. He has been a member of the varsity fencing team and secretary of the Cornell Fencers Club. Jack is also a member of Acacia fraternity and the American Contract Bridge League. In the future Jack would like to enter a managing or supervisory position for process development in one of the chemical or metallurgical industries.

Harry Fertik assumed the position of associate editor after he joined the magazine as a sophomore mechanical engineer. He was able to work on the magazine besides being in the engineering cooperative program and becoming a member of Mu Sigma Tau, the cooperative honorary. Harry is also a member of Pi Tau Sigma and Pi Delta Epsilon, mechanical engineering and journalistic honoraries. Harry says that while he was on the ENGINEER he tried to "redefine the role of the magazine on campus and to expand College News and the place of Cornell in the ENGINEER." In the immediate future he is going to graduate school to study instrumentation and automatic control.

Starting on the ENGINEER as a sophomore, Robert Bryant has risen through the offices of office manager and treasurer to his present position as business manager. While he was working for the ENGINEER, Bob also found time to become president of Pi Delta Epsilon journalistic honorary, vice president of the Engineering Council, and a member of Alpha Delta Phi fraternity. Although he will graduate as a mechanical engineer, Bob's plans for school are far from complete. He expects to get a master's degree in business from Cornell in one more year, since he was double registered in the two schools last year, and then go on to get a law degree.

Sidney Turkish joined the ENGINEER staff as a freshman EE. Since then he has held the offices of circulation manager and assistant business manager. Sid also has been treasurer of Mu Sigma Tau cooperative honorary, a member of Pi Delta Epsilon journalism honorary, and a member of Sigma Alpha Mu fraternity. Sid recently received the Pi Delta Epsilon award for the outstanding campus journalist of the year.

The retiring board members of the Engineer: Bob Bryant, Harry Fertik, Sid Turkish, and Jack Walsh.

Career Opportunities at NASA

NASA directs and implements the Nation's research efforts in aeronautics and the exploration of space for peaceful purposes and the benefit of all mankind. We offer unique opportunities in basic and applied research to scientists and engineers with degrees in the various disciplines.

Briefly described here are representative current NASA programs. Openings exist in all of these programs, at the facilities named.

SPACE TECHNOLOGY

Space vehicle development, including basic planning, development, contract coordination, and operational programming and planning for manned and unmanned satellites. Systems studies for auxiliary power supplies, air regenerative systems, instruments, guidance and communication equipment for space vehicles.

Space probes: Development and operation of vehicles, payload and instrumentation, programming and operation of flight, trajectory, communication systems, and ground support systems for near space and deep space probes.

Beltsville

SPACE MECHANICS

Experimental and analytical study of orbital mechanics including parameters of preliminary and refined orbits, ephemerides, lifetimes, equator crossings and perturbations.

Beltsville; Langley; Ames

PROPULSION AND PROPULSION SYSTEMS

Developmental studies of boosters, launchers, multi-stage engines, guidance and attitude control systems for space vehicles.

Basic research on the interrelationships between electrical, magnetic and thermodynamic energy, and application of such knowledge to space propulsion.

Magneto hydrodynamics: Research on plasma and ion accelerators for space propulsion and auxiliary power systems.

Research on reactors and reactor shielding for aeronautical and space propulsion systems.

Beltsville; Lewis

AERODYNAMICS AND FLUID MECHANICS

Investigation of the thermodynamics and transport properties of gases at high temperatures as encountered in entry into planetary atmosphere.

Research on performance, stability and control, automatic guidance, and navigation for subsonic, supersonic, and hypersonic aircraft.

Aerodynamic heating and satellite re-entry phenomena.

Langley; Ames; Lewis; High-Speed Flight Station

(Positions are filled in accordance with Aeronautical Research Announcement 61B)

INSTRUMENTATION AND COMMUNICATION

Research and development of new sensing devices and instrumentation techniques in electronics, optics, aerodynamics, mechanics, chemistry and atomic physics.

Systems studies and evaluation of control, guidance, navigation, and communication equipment for space vehicles and other high performance applications requiring rugged and compact design.

All Facilities

GEOPHYSICS, ASTRONOMY AND ASTROPHYSICS

Experimental programs and evaluation studies of astronomical and geophysical measurement and scientific equipment used in space vehicle payloads.

Studies of fields and particles in space, investigations of the composition of planetary atmospheres, and development of instrumentation and experimental techniques for these investigations.

Beltsville

STRUCTURES AND MATERIALS

Investigation of the characteristics of high temperature structures and materials. Study of fatigue, structural stability, and other problems of structural dynamics.

Solid State Physics: Study of the elementary physical processes involved in mechanical behavior of materials, such as fractures; the nature of the corrosion process; and physical-chemical relationships governing behavior of materials.

Langley; Ames; Lewis

MATHEMATICS

Application of advanced mathematical techniques to the solution of theoretical problems in aeronautical and space research, involving the use of large modern computing equipment.

All Facilities

RESEARCH FACILITY ENGINEERING

Translation of research specifications into complete experimental facilities, involving mechanical, electrical, structural, architectural and machine design, and construction engineering.

Langley; Ames; Lewis

Please address your inquiry concerning any of the programs listed here to the Personnel Director of the appropriate NASA research center:

Langley Research Center, Hampton, Virginia
Ames Research Center, Mountain View, California
Lewis Research Center, Cleveland, Ohio
High-Speed Flight Station, Edwards, California
Beltsville Space Center, 4555 Overlook Ave., Washington, D. C.

NASA National Aeronautics and Space Administration

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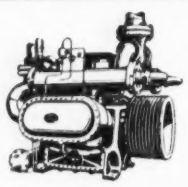

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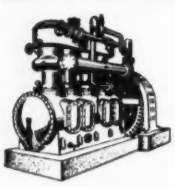

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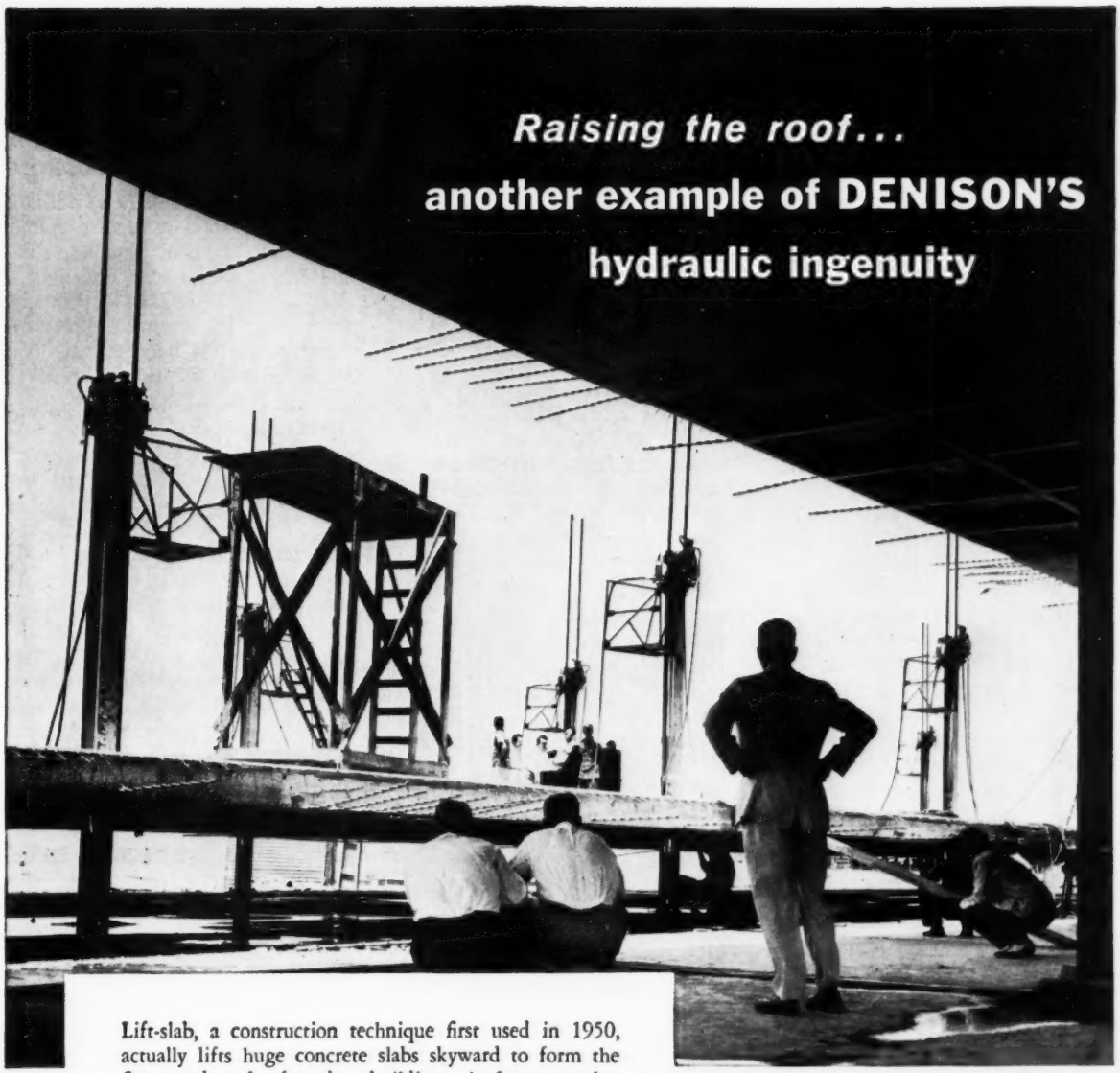

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Lift-slab, a construction technique first used in 1950, actually lifts huge concrete slabs skyward to form the floors and roofs of modern buildings. At first a novelty, the lifting of 500-ton slabs thirty feet in the air *and more* is now an everyday occurence.

The technique is simple. Concrete slabs are poured individually at ground level, cured, and then lifted one at a time to proper elevation by a series of lifting jacks or screws. In each jack, a Denison hydraulic pump/motor furnishes constant, accurately controlled torque to follow up the lifting action of the jacks.

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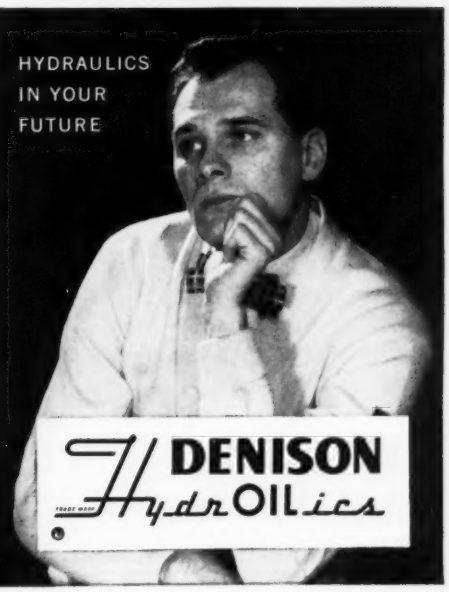

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TECHNIBRIEFS

Edited by R. H. Robinson, ME '63

RADAR CONTACT WITH VENUS PROVIDES VALUABLE DATA

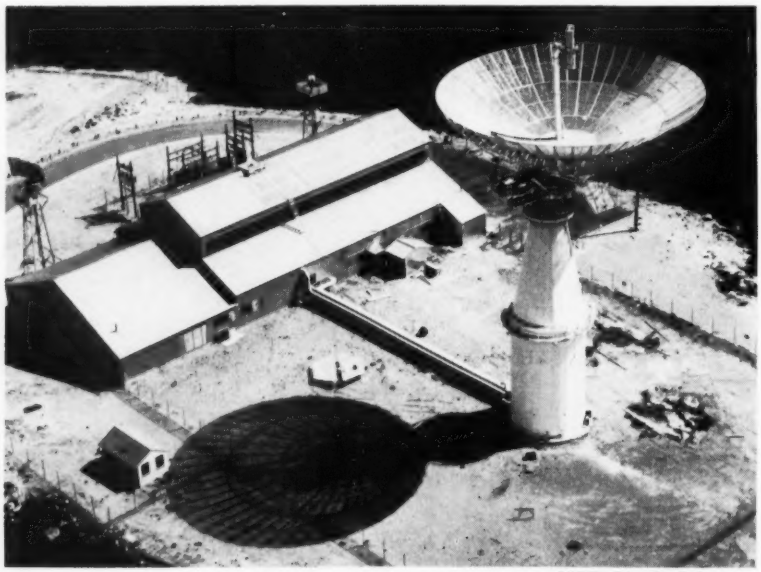
The first successful attempt to establish radar contact with the planet Venus has been reported by a research team at the Lincoln Laboratory at the Massachusetts Institute of Technology. This experiment with radar astronomy achieved a one hundredfold increase in the longest range ever attained with radar and is the first instance of a direct two-way contact with any celestial body beyond the moon.

This contact was made at a distance of approximately 28 million miles, the radar waves having been detected after travelling the round-trip distance of 56 million miles.

The experiment was conducted on February 10 and 12, 1958. Since the returning radar pulses were too faint to be observed directly or measured individually, the received signals were recorded on magnetic tape and subjected to exhaustive analysis by a high-speed digital computer. Approximately a year has been required to develop and use the intricate computing methods which were necessary to isolate the returned radar signals from electrical noise mixed in with the recorded data.

In recent years, astronomers have been eagerly awaiting the first radar detection of any one of the planets because of the great accuracy with which radar can measure distances. Distances between planets are already known to a high degree of precision, but the distances between the earth and these planets are only roughly known. The more accurate determination of the distance from the earth to any one planet would then make it possible to calculate all other interplanetary distances more accurately.

The Lincoln Laboratory experiment has produced two highly accurate measurements of the round-trip travel time of radar signals between the Earth and Venus. When properly interpreted, these measurements of time should make it possible to fix the size of the solar system to an accuracy of one-thousandth of one per cent, an accuracy almost one hundred times greater than has been possible by the most refined optical methods. Preliminary calculations from the Lincoln data indicate that the dimensions of the solar system are somewhat smaller than the previously accepted values, but this interpretation requires further study.



M.I.T. Lincoln Laboratory

M.I.T. Lincoln Laboratory's Millstone Hill Radar Observatory recently made the first radar contact with the planet Venus.

'HOT-COLD-LIGHT' PANEL UNVEILED BY WESTINGHOUSE

Wall or ceiling panels, perhaps no thicker than a picture frame, may some day cool a home in summer, heat it in winter, and light it the year round. The first experimental model of such a three-purpose panel has been revealed by Westinghouse Electric Corporation.

The experimental panel combines into a single operating unit two of man's newest technological advances, thermoelectric refrigeration and electroluminescent lighting. Thermoelectric refrigeration produces cooling in certain solid materials directly from the flow of an electric current. Electroluminescent lighting is produced by glowing panels no thicker than a sheet of ordinary window glass.

The new foot-square "hot-cold-light panel, composed entirely of solid state materials, has no moving parts. It produces as much light as a twenty-five-watt bulb, can maintain a surface temperature approaching that inside a household refrigerator, and, by the flick of a switch, can raise that surface temperature to about 130 degrees Fahrenheit—a temperature suitable for radiant heating.

COOL-RUNNING RADIO TUBE LASTS LONGER AND USES LESS POWER

Development of a new, cool-running radio tube, considered the first major breakthrough in basic tube design in thirty years, has been announced by the Department of the Army. The radically new tube, developed jointly by the U. S. Army Signal Research and Development Laboratory and Tung-Sol Electric Incorporated, glows blue instead of red and uses less than one-tenth the power of a standard hot-cathode tube.

This radio tube could be the forerunner of a new line of general-purpose tubes for broad military and civilian use. Due to its potential reliability, the tube may outlast any equipment in which it is used. In the future, radios and TV sets equipped with cold tubes may rarely need tube replacement.

Like other electron tubes, the new tube is extremely resistant to heat and atomic radiation. These properties are important in military equipment which may have to withstand nuclear blasts or the searing heat of missile nose-cones.

The cold-cathode principle is believed adaptable to almost all types of electron tubes including TV screens and giant radar and transmitting tubes, as well as nearly all general-purpose radio tubes. Miniature and sub-miniature tubes, which would compare favorably with the transistor in size, may also be feasible.

Ordinary tubes have always required a red-hot cathode element to generate needed electrons. This heating takes a large percentage of the power and forces the use of more complicated circuits or extra batteries. In the new tube, the hot element is replaced by a cold cathode, which is a tiny nickel cylinder specially coated with porous magnesium oxide. Instead of heat, a high voltage field causes the electron flow, which in turn produces the tube's characteristic phosphorescent blue glow.

Models of the new tube spring to life as soon as they are turned on, while ordinary tubes require several seconds for warm-up. Discovery of the new device may eventually lead to the development of smaller, faster-acting walkie-talkies, and simplified design of other communications gear where the heat generated by conventional tubes poses serious problems.

GAS TURBINE DEVELOPED FOR TRUCK-CAR USE

Development of a unique supercharged gas turbine engine of 300 horsepower was announced today by Ford Motor Company. Its weight is only one-fourth that of a truck diesel engine of comparable horsepower while its fuel economy rivals that of a diesel and is superior to that of a conventional gasoline engine under most operating conditions.

Earlier gas turbines designed for trucks and passenger cars have employed one stage of air compression. The new Ford turbine has two—one a supercharging stage which enables the engine to deliver more horsepower from a smaller size. Each compressor stage effects a four-to-one air compression. The low speed compressor turns at 46,500 revolutions per minute and the high speed one, at 91,500 revolutions per minute.

Early gas turbine designs had only one combustion chamber while the new turbine has two burners. Both the primary and the re-heat combustion chambers operate at 1,700 degrees Fahrenheit. Exhaust gases are discharged at about 740 degrees Fahrenheit, which is roughly the same temperature as conventional passenger car exhausts.

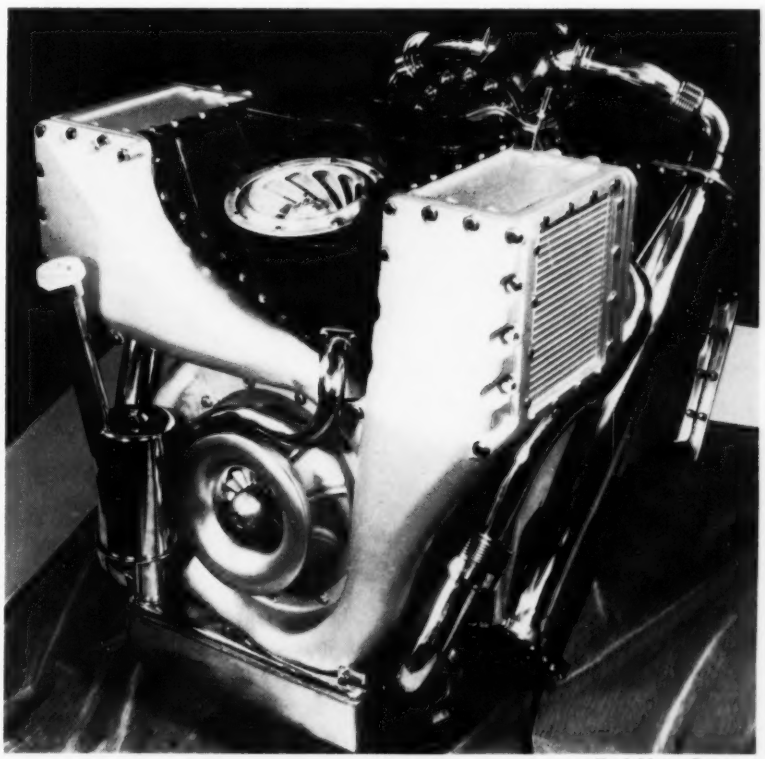
The new engine is efficient over a wide range of power outputs. Maximum fuel economy can be obtained anywhere in the range from 25 to 100 per cent of full power whereas earlier designs had good efficiency only when operating at near full power.

UNDERGROUND SHELTER PROTECTS AGAINST ATOMIC WEAPONS

An underground shelter for protection against atomic weapons has been constructed by the U. S. Army Engineer Research and Development Laboratories. The corrugated metal structure is designed for use in overseas theaters of operations and has been tested with conventional explosives under high explosive blast conditions.

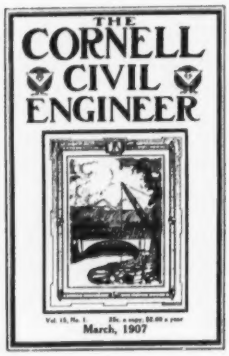
The tests indicated that the new shelter can withstand blast pressures of up to sixty pounds per square inch. The primary purpose of the tests was to evaluate the entrance, blast protector, and ventilation designs. The manually-powered ventilation system was tested by forty volunteers who spent twenty-four hours in the shelter without incident.

The shelter is formed of heavy corrugated steel plates bolted together in the shape of a parabolic arch. The crown height of seven feet affords ample headroom. The test unit, which is sixty-eight feet long and ten feet wide, was placed in an excavation eleven feet deep, and covered with four feet of soil. Entrance to the shelter is through two combined vertical and horizontal tubes, each three feet in diameter and thirty feet in overall length, capped with a perforated blast cover and door. At ground surface, rocks are placed around the tubes to a depth of five feet to form a blast stopper.



Ford Motor Company

This is the "704", a supercharged gas turbine engine developed by Ford Motor Company.



FIFTY YEARS AGO IN THE ENGINEER

Edited by J. F. Shapiro, ME '61

The abolition of the Spring vacation would work a greater hardship on the students of Sibley College than on the members of the other departments of the University. One argument that has been offered in favor of abolishing the recess, which practically splits the second term in half, is that there is difficulty in getting the men to take up their work where they left off with the proper alacrity and interest. We feel that this condition, while undesirable, is more desirable than one wherein the students would be in such mental and physical condition as to make their work by the end of the term not only disinterested but poor. Sibley College work is of such a nature, and the time devoted to it so scheduled that late night hours become inevitable. This is true especially of the upper classes. The great number of reports which have to be written up, involving long and tedious calculations, are done in most cases in one or two sittings. This of course is wrong, but still the majority of the men find that more work can be done if a job is "stuck to" until finished even though it takes until morning. If all the work that had to be done could be confined to nine continuous hours of work a day then things would be different. The students' work would then be more of the character of that he would meet in the Engineering and business world. However the demand of athletics and other university activities has forced the faculty to shorten as far as possible the afternoon work. "Eight o'clocks," short lunch hours in shop, all eliminate considerable time from afternoons. (*The Sibley Journal of Engineering*, May, 1909)

We are living in the automobile age of road construction, or perhaps more strictly speaking, we are just entering upon a new era, inasmuch as the introduction and popular use of the auto have put before us problems which have been overlooked for the ten or twelve years previous.

The evolution of the highway in America has been from the winding Indian trail, along step by step, including the old Post-roads, to the beautiful country boulevards of today. Not only do we build roads for the purpose of transporting persons and goods from place to place, or garden truck from the farm to the market, but for pleasure. They are windows to the soul of the State, opening up tracts of land in the remote parts, always beautiful, but undiscovered, and inaccessible until the auto took its popular place in the hands of the idle rich. (*The Civil Engineer*, May, 1909)

The bill introduced in the Idaho House of Representatives licensing engineers was defeated. The gentleman who spoke against the bill characterized it as "forming a codfish aristocracy with the State Engineer at the head." (*The Civil Engineer*, May, 1909)

The time has come for the Senior class to step forth from the battle of the books and begin the battle of life. Without doubt, in the years to come, we shall think with regret of the care-free days of our college lives. Yet now there is scarcely one who is not anxious for the real work to begin and to find out what the future has in store for him.

. . . On taking up a position, we shall find that our real education in engineering has only begun. The theories which we have been taught at college have been sufficient for us to at least grasp any problem we may have to face, but the difficulty now lies in making these theories successful in practice. Some will succeed, others fail. Possibly some of those who fail will be among the ones who made the highest marks in college. As expressed by one of our alumni, it is breadth of mind, and not breadth of knowledge, which counts for success in life.—(*The Civil Engineer*, May, 1909)

Work on the Manhattan Bridge across the East River, New York, is progressing in such a satisfactory manner that it will probably be opened for foot-passenger and vehicular traffic by the close of the present year. So far the four wire cables, 21¼ inches in diameter, have been strung, and the suspender cables placed in the cast steel saddles. All the steel for the structure has been stored in the local yards. The bridge when completed will be the largest and heaviest ever built. It will carry a 35-foot roadway and two 11-foot sidewalks. On the same deck provision is made for four surface trolley tracks. On the upper deck there will be four rapid transit tracks. (*The Cornell Civil Engineer*, April, 1909)

Dean Haskell has made the following rules regarding the smoking room:

1. Windows must be kept open.
2. Feet must be kept off the tables.
3. Cuspidors shall only be used for the purpose for which they are made and not as waste paper baskets, etc. (*The Cornell Civil Engineer*, October, 1908)

Stress & Strain

Edited by D. J. Martin, EE '62

A man boarded a pullman and gave the porter $5 to wake him when the train reached Podunk at 4 A.M. "Now, porter, I'm a very heavy sleeper, so you may have to drag me out of the berth, put my clothes on me, and carry me out to the platform. And no matter how much I resist, don't pay any attention."

Next morning the man awoke to find himself in New York. Boiling mad, he sought out the porter and roundly cussed him out.

The porter shook his head in admiration. "Boss, you sho' has got a temper, but it ain't nothing to compare to the gent'man's that I put off the train this mornin' at Podunk."

° ° °

"So your boy's at college! What's he going to be when he gets through?"

"Senile."

° ° °

1st Korean Vet: "And there we were on top of that shell-torn hill, fighting for our very lives, odds 200 to one."

2nd Korean Vet: "Boy that must have been rough."

1st Korean Vet: "You said it. That was the meanest Chinaman I ever saw."

° ° °

The bandaged CE who lay in the hospital bed spoke dazedly to his visiting pal.

"What happened?"

"You absorbed too much last night and then made a bet you could fly out the window and around the block."

"Why didn't you stop me?" screamed the beat-up student.

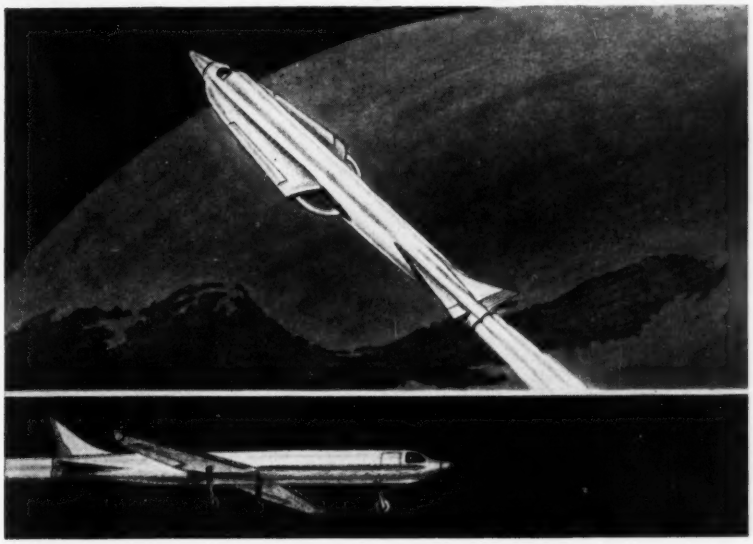
"Stop you, man," said the other. "I had $25 on you."

° ° °

A minister, making a call, and his hostess were sitting in the parlor when Junior came running in, carrying a dead rat.

"Don't worry, Mother, it's dead. We bashed him and beat him until—", and noticing the minister for the first time, he added in a lowered voice—"until God called him home."

MARS outstanding design **SERIES**

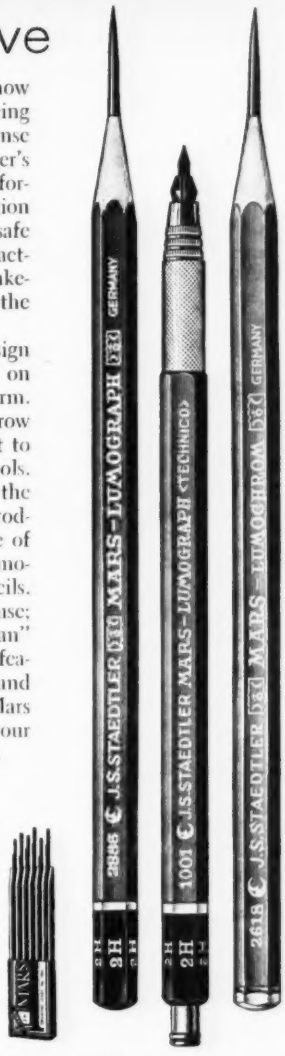


brings 'em back alive

Today's burning problem in space flight is how to ease a rocket safely back to earth, without being consumed by the metal-melting friction of our dense atmosphere. Design Engineer Carl J. Rauschenberger's ingenious suggestion is a pair of wings, locked forward at blast-off, later folded back into flying position (insert) by hydraulic cylinder controls for a slow, safe descent. Mr. Rauschenberger also envisions a retractable glass nose cone, heatproof to withstand the take-off, drawn back to admit air to a jet engine on the return flight.

This outstanding solution to a timely design problem may already exist in working drawings on somebody's drafting board, or even in mock-up form. But whether a project is developed today, tomorrow or the year after next, it will always be important to shape ideas into realities with the best of drafting tools.

In pencils, of course, that means Mars, long the standard of professionals. Some outstanding new products have recently been added to the famous line of Mars-Technico push-button holders and leads, Lumograph pencils, and Tradition-Aquarell painting pencils. These include the Mars Pocket-Technico for field use; the efficient Mars lead sharpener and "Draftsman" pencil sharpener with the adjustable point-length feature; Mars Lumochrom, the color-drafting pencils and leads that make color-coding possible; the new Mars Non-Print pencils and leads that "drop out" your notes and sketches when drawings are reproduced.



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Though the building is not yet built, this is a view from one of the apartments.

How to look out a window before the building is up

With 180 "view" apartments to sell, the developers of The Comstock turned to photography to get a jump on sales

A feature of The Comstock, San Francisco's new co-operative apartments on top of Nob Hill, will be the spectacular panoramic views of the Bay area from their picture windows.

How could these views be spread before prospective buyers—before the building was up? The developers, Albert-Lovett Co., found the answer in photography. From a gondola suspended from a crane, color photos were made from the positions of the future apartments. Now, the sales representative not only points out the location of a possible apartment on a scale model, but shows you the view from your window as well.

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One of a series

General Electric interviews Dr. Richard Folsom, President of Rensselaer Polytechnic Institute, to explore . . .

Teaching— A Career Opportunity For the Engineer

Leading educators, statesmen and industrialists throughout the country are greatly concerned with the current shortage of high-caliber graduates who are seriously considering a career in the field of science or engineering education. Consequently, General Electric has taken this opportunity to explore, with one of America's eminent educators, the opportunities and rewards teaching offers the scientific or engineering student.

Q. Is there in fact a current and continuing need for educators in technical colleges and universities?

A. Colleges and universities providing scientific and engineering educational opportunities are hard pressed at the present moment to obtain the services of a sufficient number of well-qualified teachers to adequately carry out their programs. Projected statistical studies show that this critical need could extend over the next 15 or 20 years.

Q. Why is this need not being met?

A. There are probably three main reasons. These might be classed under conditions of financial return, prestige associated with the position, and lack of knowledge and understanding on the part of the college student of the advantages and rewards teaching as a career can afford.

Q. What steps have been taken to make education a more attractive field to engineering students?

A. Steps are being taken in all areas. For example, we have seen a great deal in the newspapers relating educators' salaries to the importance of the job they are doing. Indications are that these efforts are beginning to bear fruit. Greater professional stature is being achieved as the general public understands that the youth of our nation is the most valuable natural resource that we possess . . . and that those associated with the education of this youth have one of the most important assignments in our country today.

Q. Aside from salary, what rewards can a career in education offer as opposed to careers in government or industry?

A. The principal rewards might be freedom to pursue your own ideas within the general framework of the school, in teaching, research and consulting activities. As colleges and universities are normally organized, a man has three months in the summer time to engage in activities of his own choice. In addition, the educator is in direct contact with students and he has the satisfaction of seeing these students develop under his direction . . . to see them take important positions in local and national affairs.

Q. What preparation should an engineering student undertake for a teaching career?

A. In college, the engineering student should obtain a basic understanding of science, engineering science, humanities and social sciences with some applications in one or more professional engineering areas. He should have frequent career discussions with faculty members and his dean. During graduate work, a desirable activity, the student should have an opportunity to do some teaching.

Q. Must an engineering student obtain advanced degrees before he can teach?

A. It is not absolutely necessary. On the other hand, without advanced degrees, advancement in the academic world would be extremely difficult.

Q. How valuable do you feel industrial experience is to an engineering or scientific educator?

A. Industrial experience for a science educator is desirable; however, with a senior engineering educator, industrial experience is a "must". An ideal engineering educator should have had enough industrial experience so that he understands the problems and responsibilities in carrying a project from its formative stages to successful completion, including not only the technical aspects, but the economic and personal relationships also.

Q. What do you consider to be the optimum method by which an educator can obtain industrial experience?

A. There are many methods. After completion of graduate school, perhaps the most beneficial is a limited but intensive work period in industry. Consulting during an academic year or summer is a helpful activity and is desirable for older members of the staff. Younger educators usually need experience in "living with the job" rather than providing consultant's advice to the responsible individual.

Q. Based on your experience, what personal characteristics are possessed by successful professors?

A. Primarily, successful professors have an excellent and growing knowledge of their subjects, are interested in people, and transmit enthusiasm. They have an ability to explain and impart information with ease. They generate ideas and carry them out because they are devoted to developing their fields of knowledge. They desire personal freedom and action.

For further information on challenging career opportunities in the field of science and engineering education, write to: Mr. W. Leighton Collins, Secretary, American Society for Engineering Education, University of Illinois, Urbana, Ill.

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